FIRST

# REPORT

OF THE

## DEPARTMENTAL COMMITTEE

APPOINTED TO INQUIRE INTO THE

# VENTILATION OF FACTORIES AND WORKSHOPS;

## WITH APPENDICES.

Presented to both Houses of Parliament by Command of His Majesty.

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1902.

[Cd. 1302.]

## MINUTE APPOINTING COMMITTEE.

I appoint Dr. JOHN SCOTT HALDANE, F.R.S., and Mr. E. H. OSBORN, Engineering Adviser to the Chief Inspector of Factories, to be a Committee to inquire into and report upon (*a*) the means of ventilation in factories and workshops, with especial reference to the use of fans; (*b*) the use and construction of respirators for the protection of workpeople exposed to dust or dangerous fumes.

I appoint Mr. C. R. PENDOCK, Inspector of Factories, Secretary to the Committee.

Whitehall, 13 July 1900. (signed) M. W. RIDLEY.

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# FIRST REPORT of the DEPARTMENTAL COMMITTEE appointed to inquire into the VENTILATION of FACTORIES and WORKSHOPS.

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To the Right Honourable ARETAS AKERS-DOUGLAS, M.P., His Majesty's Principal Secretary of State for the HOME DEPARTMENT.

Sir, 15th August 1902.

We have the honour to submit to you the following First Report on the Ventilation of Factories and Workshops :—

It is evident that the air breathed by the employees in a factory or workshop can be kept pure in two ways : (1) by constantly renewing from outside the whole of the air of the room in which work is carried on : (2) by removing impurities locally, or otherwise preventing them from ever mixing with the air breathed. The former process may be distinguished as general, and the latter as local ventilation. As a general rule dust and fumes can best be dealt with by local ventilation or other means, whereas impurities due to the presence of employees, and of lights burning, must be got rid of by general ventilation. In the present Report we propose to deal only with general ventilation, which is necessary in all cases, whether local ventilation may also be required or not. In a further Report we hope to refer to local ventilation and other means of preventing injury to health by dust and fumes.

All authorities are agreed that health depends to a large extent on a constant and abundant supply of fresh air uncontaminated by other individuals or by any substances which cause discomfort or contain poisonous, infective, or otherwise harmful material. The air of a building containing human beings cannot, however, be kept absolutely pure ; and all that can be demanded for the air of factories and workshops is that it should be kept as pure as is reasonably practicable.

By section 7 of the Factory and Workshop Act, 1901, it is enacted that "in every room in any factory or workshop sufficient means of ventilation shall be provided and sufficient ventilation shall be maintained" : also that "the Secretary of State may, by Special Order, prescribe a standard of sufficient ventilation for any class of factories or workshops, and that standard shall be observed in all factories or workshops of that class, and an order made under this power may supersede any provision of this Act or order of the Secretary of State in cotton cloth factories."

By the effects of the air upon the senses one can roughly judge as to whether a room is sufficiently ventilated according to one's own subjective standard ; but the judgments of different persons agree only very roughly, and are liable to be affected by various incidental circumstances. It is therefore desirable to have an objective criterion of what constitutes reasonably "sufficient" ventilation.

Except in cases where artificial ventilation by fans is employed, it is seldom practicable to measure directly with an anemometer the amount of air supplied per person in a building; and the only practical objective criterion hitherto legally recognised in general administration in connection with all factories and workshops is the existence of a certain minimum (250 cubic feet) of air-space per person employed. As is shown in Appendix II, however, the existence of a certain cubic air-space per person affords no reliable guarantee of reasonably sufficient ventilation, and indeed, the most highly vitiated air met with by the Committee was in rooms with an air-space of about 10,000 cubic feet per person, or forty times the legal minimum.

It has long been recognised that the best objective criterion of the sufficiency of ventilation in ordinary rooms is the proportion of carbonic acid in the air ; and one of the chief points to occupy our attention was the question whether it is practicable to make use of this proportion as a legal standard of sufficient ventilation. The objection to such a standard appeared to be that the analysis of the air, if carried out with sufficient accuracy, was a troublesome and therefore expensive process, involving (1) the collection in a large bottle, and conveyance to a laboratory of a sample of the air : (2) laboratory manipulations requiring considerable expenditure of time.

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With a view to meeting these difficulties a method of analysis, which we have made use of throughout the experimental part of our inquiry, was devised by one of us, and is described in Appendix III. By this method the analysis can be done on the spot within less than five minutes, if the apparatus, which is easily carried about, is brought to the room requiring examination; or the sample required can be collected in a very small bottle, such as can be carried without inconvenience, and the analysis made at leisure.

In order to obtain a general idea as to the means of ventilation commonly adopted, and the proportions of carbonic acid actually present in the air under ordinary conditions of work, we have without previous notice visited a large number of factories and workshops and made analyses of the air—in many cases on the spot. The results will be found in Appendix I.

Standards have been laid down by various authorities as to the proportion of carbonic acid which ought not to be exceeded in the air of rooms. These standards are based partly on the unpleasant effects of air containing more than a certain proportion of carbonic acid due to respiration or artificial lights, and partly on what has been found to be a practically attainable standard of purity. The limit originally proposed by Pettenkofer (1) was 10 volumes of carbonic acid per 10,000 volumes of air or 6 volumes in excess of the proportion commonly found in the air of towns. De Chaumont (2) as the result of observations on the air of barracks, proposed as low a limit as 6 volumes per 10,000. On the other hand, Carnelley, Haldane, and Anderson (3) concluded in 1887 that for the very crowded elementary schools of this country a lower limit than 13 volumes could not for practical and financial reasons be fixed, although with the present improved facilities for mechanical ventilation a much lower practical limit could doubtless now be assigned. From our own observations we have come to the conclusion that it is reasonable to expect that under ordinary circumstances 10 volumes should not be exceeded in factories or workshops unless gas is burning.

The only instance in which a standard of purity has been fixed by law in this country is in the case of the artificially humidified air of cotton-cloth weaving sheds. The maximum limit of carbonic acid allowed at any part of the factory is 9 volumes per 10,000. This regulation, which is only enforced during daylight, has resulted in great benefit, but is in our opinion somewhat stringent, except with a view to cases in which much gas is burnt during morning or evening hours in winter.

We are of opinion that it would materially assist towards efficiency in the ventilation of factories and workshops generally if a maximum limit of carbonic acid allowable in the air during both daylight and gaslight were fixed in virtue of the power conferred on the Secretary of State by the Factory Act of 1901. We have found that as a general rule employers, and particularly the larger ones, are willing and anxious to do all that is within their power to secure efficient ventilation of their factories and workshops, and that frequently the result of their efforts is admirable. Where failure occurs this often depends on thoughtless objections on the part of a small minority of the employees. We believe that the laying down of a legal standard would lead to such objections being overcome, and to much more attention being given to the proper utilisation of existing means of ventilation. We also believe that it would have a good effect in preventing much wasteful expenditure on inefficient ventilators, &c., as it would supply a ready test of efficiency. While it would act as a means of putting pressure on backward or negligent employers it would serve to protect from unjust criticisms those who have done what can reasonably be expected.

We also think that the legal limit ought not to be fixed as low as the ordinary working limit. It may easily occur (particularly where ordinary methods of ventilation without the use of fans are employed, as is generally the case) that the air of a room which is usually fairly well ventilated, has in consequence of exceptional conditions become temporarily, or in particular parts, somewhat foul. A margin ought therefore to be allowed in order to meet such cases; also to cover any uncertainties due to slight variations in the proportion of carbonic acid in the outside air, or to unavoidable errors of analysis.

In sedentary occupations the objection on the part of employees to proper ventilation depends sometimes on the absence of proper warming arrangements during cold weather. This often leads to further vitiation of the air through the lighting of gas-burners for heating purposes during the day—a wasteful and objectionable plan.

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(1) Ueber den Luftwechsel in Wohngebäuden, 1858, p. 78.
(2) Proceedings of the Royal Society. No. 168, 1875, No. 171, 1876.
(3) Philosophical Transaction of the Royal Society, 1887, B. p. 102.

The establishment of a legal maximum limit of carbonic acid would probably conduce to the provision and use of proper heating appliances in such cases. We are of opinion that heating arrangements capable of maintaining in case of necessity a temperature at least 25° F. above that of the outside air, in the absence of lights and employees but along with adequate ventilation, should be provided in all factories and workshops where the occupation is sedentary or involves little muscular exertion, and should be regularly used in the colder weather. In such occupations the temperature should not be less than about 60° F., particularly where the work involves delicate manipulations with the hands.

## RECOMMENDATIONS.

After very careful consideration we desire to make the following recommendations :—

1. That in exercise of the powers conferred on the Secretary of State, by section 7 of the Factory Act of 1901, such a standard of ventilation should be prescribed for all classes of factories and workshops not otherwise specially dealt with, that the proportion of carbonic acid in the air at about the breathing level, and away from the immediate influence of any special source of contamination, such as a person or light, shall not (except on very foggy days, when no tests should be made, on account of the vitiated state of the outside air) rise during daylight, or after dark when only electric light is used, beyond 12 volumes of carbonic acid per 10,000 of air, and that when gas or oil is used for lighting the proportion shall not exceed 20 volumes after dark or before the first hour after daylight; the only exception to this rule to be in cases where the extra carbonic acid is produced in other ways than by respiration or combustion, as in breweries, &c.

2. That in the case of cotton-cloth factories with artificially humidified air the occupier should have the option of coming under the regulation just mentioned, instead of remaining under the existing regulation.

3. That Inspectors of Factories should inform employers of the results of any official analyses of the air in their factories or workshops, should give notice that the ventilation is deficient to any employer in whose factory or workshop the above proportions have been found to be exceeded, and at the same time supply, so far as practicable, information as to the nature of any defect noticed; and that legal proceedings should not be taken against an employer unless, after a reasonable interval following such notice, the stated proportion is found, on an average of two or more samples taken in different parts of the room, to be again exceeded by one volume or more, and he is unable to show that he has taken measures reasonably calculated to secure the requisite ventilation.

4. That arrangements be made by the Factory Department of the Home Office for the analysis by a specially qualified person or persons of samples of air collected by Inspectors (*see* Appendix III), and that any analysis on which a prosecution immediately depends shall have been performed by such qualified person or persons.

5. That arrangements be made for Inspectors of Factories to have the use, when desired, of a properly tested portable apparatus for estimating on the spot the proportion of carbonic acid in air.

In Appendix II we have endeavoured to give a general account of the conditions on which efficient ventilation depends. We trust that this information may prove of service both to the Factory Department and to Employers.

We have the honour to be, Sir,

Your obedient Servants,

JOHN SCOTT HALDANE.

EDWARD H. OSBORN.

CHARLES R. PENDOCK, Secretary.

# APPENDIX I.

## Results of Examination of Ventilation.

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## INTRODUCTION.

The present Appendix contains a series of Tables giving the results of the examination by the Committee of the general ventilation of factories and workshops visited by them in the course of their inquiries. To facilitate reference the Tables are classified according to the nature of the work. The carbonic acid determinations were made by the method described in Appendix III., partly on the spot and partly from samples collected in bottles.

The determinations of bacteria, which were only made in a few cases, were by a slightly modified form of Frankland's method (Philosophical Transactions, 1887, B.) The air was drawn through a sterilised plug of glass wool by means of a brass syringe of known capacity, the number of strokes of which served as a measure of the volume of air taken. The glass tubes containing the glass wool plugs were each enclosed in a separate outside sterilised glass tube, with an asbestos plug. On this outside tube the label was placed. In taking the sample of air the inside tube was attached directly to the pump by means of a short piece of stout rubber tubing. The plug was afterwards transferred, with the necessary precautions, to a shallow flat-bottomed flask, containing a small quantity of liquefied nutrient jelly, which was shaken so as to disintegrate and spread the glass wool. The jelly having been allowed to set, the flask was kept at a temperature of 20 degrees C. till no further colonies of bacteria or moulds developed. The number of colonies which grew indicated the number of bacteria in the air taken.

In cases where two temperatures are given these refer to readings of the dry and wet bulb thermometers.

For nearly all the analyses of air in file-cutting workshops we are indebted to Dr. Robertson, Medical Officer of Health for Sheffield, who very kindly placed at the disposal of the Committee a number of unpublished data obtained by himself. His analyses will be found in Table L.

## TABLE A.

## CLOTHING FACTORIES.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 | Wholesale tailoring, Bethnal Green, E., 14 Jan. 1901. | Top floor, fourth (cutting room). | 30,780 | 15 | 16 | 1,924 | – | 14 Jan. 1901, 3.0 p.m. | Body of room | – | 13·8 | 3·5 (Estimate). | – | – | Windows and skylights; none open. | Referred to the Committee as indifferently ventilated. No means of heating except by gas jets. Clean, wholesome room. Impure air evidently came through hoist and stairs from below, as shown by the second analysis. |
| 2 | - ditto - ditto | - ditto - ditto | 30,789 | 15 | 16 | 1,924 | – | 14 Jan. 1901, 3.5 p.m. | Over stairs from below. | – | 14·1 | ditto | – | – | — | |
| 3 | - ditto - ditto | - ditto - ditto | 30,780 | 15 | 16 | 1,924 | Gas, 28 jets. | 14 Jan. 1901, 4.30 p.m. | Body of room | – | 19·7 | ditto | – | – | Windows and skylights; none open. | Second test made with gas nearly all alight, 1½ hours later. |
| 4 | - ditto - ditto | Second floor (machine room). | 22,572 | 11 | 65 | 347 | Gas, 32 jets. | 14 Jan. 1901, 4.15 p.m. | - ditto - | – | 15·1 | ditto | – | – | Eleven windows dropped 9 to 12 inches from top. | A second test at 4.40 p.m. gave a higher reading than this at 4.15. Heat from gas probably increased ventilation. |
| 5 | - ditto - ditto | - ditto - ditto | 22,572 | 11 | 65 | 347 | Gas, 32 jets. | 14 Jan. 1901, 4.40 p.m. | - ditto - | – | 12·4 | ditto | – | – | - ditto - ditto - | At or about 4.30 p.m. the readings were:—top floor 19·7; third floor 17·4; second floor 12·4. Showing that bad air accumulated on upper floors from floors below. |
| 6 | - ditto - ditto | Third floor (machine room). | 52,572 | 11 | 50 | 450 | Gas, 20 jets. | 14 Jan. 1901, 4.35 p.m. | - ditto - | 70½ | 17·4 | ditto | – | – | Five windows open. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 | Wholesale tailoring, Whitechapel, E., 22 Feb. 1901. | Top floor, fourth (cutting room). | 67,500 | 12½ | 50 | 1,350 | Gas, 37 jets. | 22 Feb. 1901, 4.32 p.m. | - ditto - | 63 | 35·8 | 3·5 (Estimate.) | 17 | 22 | Very deficient. Side windows all closed, no opening in roof. Hoist well from below, but no current. | This room was lofty and spacious. Thinly occupied and no regard was paid to ventilation. Gas jets were solely depended upon for heating and had been alight a considerable time. The air was consequently stagnant and impure. |
| 8 | - ditto - ditto | - ditto - ditto | 67,500 | 12½ | 50 | 1,350 | ditto | 22 Feb. 1901, 4.40 p.m. | - ditto - | 63 | 36·0 | 3·5 (Estimate.) | – | – | — | |
| 9 | Wholesale tailoring, Whitechapel, E., 19 Mar. 1901. | - ditto - ditto | 67,500 | 12½ | 50 | 1,350 | – | 19 Mar. 1901, 2.25 p.m. | - ditto - | – | 20·2 | 3·5 (Estimate.) | Lost | Lost | Very deficient. Side windows all closed, no opening in roof. Hoist well from below, but no current. | This test was made on a clear, light day to compare with results of a month previous, when gas was lit. Although the weather was cold and inclement no gas was on, and the results (still high) were much below last test. |
| 10 | - ditto - ditto | Third floor (forwarding department). | 57,600 | 10⅔ | 10 | 5,436 | – | 19 Mar. 1901, 2.40 p.m. | - ditto - | – | 21·0 | 3·5 (Estimate.) | – | – | No openings except hoist well above and below. | The space per person here was four times greater than on top floor, yet the $CO_2$ was slightly higher; other conditions being about the same. |
| 11 | - ditto - ditto | First floor (forwarding department). | 57,600 | 11⅝ | 20 | 3,195 | – | 19 Mar. 1901, 2.50 p.m. | - ditto - | – | 18·4 | 3·5 (Estimate). | 2 | 0 | No special openings. Hoist well above and below. | It is noticeable that although twice as many people were employed in the same space as on floor immediately above, the $CO_2$ was lower; other conditions being much the same. |
| 12 | Wholesale tailoring, Whitechapel, E., 22 Feb. 1901. Women's factory. | Top floor, fourth (girls' machine room). | 21,953 | 16 | 63 | 348 | E.L. | 22 Feb. 1901, 3.20 p.m. | - ditto - | 67 | 9·2 | 3·5 (Estimate). | 8 | 1 | Four windows in roof, partly open; stairs with door open to roof. Hoist from below. | A remarkable feature in the ventilation here was the great volume of air coming up through hoist, calculated to be 6,000 cubic feet per person per hour. |
| 13 | - ditto - ditto | Third floor (L-shaped machine room). | 18,636 | 14 | 57 | 327 | E.L. | 22 Feb. 1901, 3.35 p.m. | - ditto - | 65 | 10·0 | 3·5 (Estimate). | 9 | 8 | Nine large fanlights, three open. Stairs and hoist as in room above. | Very clean and wholesome looking rooms, floors swept daily and scrubbed once a week. Steam-heated throughout. |
| 14 | - ditto - ditto | Second floor (machine room), as above. | 30,439 | 14 | 110 | 276 | E.L. | 22 Feb. 1901, 3.50 p.m. | - ditto - | 65 | 7·4 | 3·5 (Estimate). | 3 | 0 | Fifteen fanlights, six open. Hoist and stairs up and down. | As above. |
| 15 | - ditto - ditto | First floor (as above). | 27,797 | 14 | 120 | 231 | E.L. | 22 Feb. 1901, 3.55 p.m. | - ditto - | 66 | 10.6 | 3·5 (Estimate). | – | – | As above - - | From the figures given this room was overcrowded at the time of test. |

TABLE A.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8). | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 16 | Wholesale tailoring, Whitechapel, E., 22 Feb. 1901. Women's factory. | Small part of ground floor (hand sewing). | 9,800 | 14 | 8 | 1,212 | E.L. | 22 Feb. 1901, 4.20 p.m. | Body of room | – | 7·4 | 3·5 (Estimate). | 9 | 0 | Nothing open | Small, clean room, thinly occupied. |
| 17 | - ditto - ditto | Basement (pressing room). | 29,787 | 17 | 20 | 1,489 | E.L. also gas iron stoves. | 22 Feb. 1901, 2.50 p.m. | - ditto - | – | 9·2 | ditto | – | – | One 36-in. Blackman fan with no outlet (not working). One "Paddle" fan working overhead. One side window at pavement level open. Stairs and hoist to floor above. Underground passage to other factory. | Referred to the committee as unsatisfactory. The large propeller fan was not working. It was fixed so as to be practically useless. The overhead paddle fan was at work, creating currents without any purifying effect. |
| 18 | Wholesale clothing, Chatham, 31 May 1901. | First floor (women's machine room). | 94,809 | 13 | 105 | 903 | – | 31 May 1901, 1.30 p.m. | - ditto - | – | 4·1 | ditto | 1 | 0 | Six ridge ventilators all open, fifteen fanlights all open, one door, one stove with flue. | This test was made on a very fine, warm day, when the windows could all be opened, and only two-thirds the usual number of hands were working. |
| 19 | Wholesale tailoring, Whitechapel, E. Same as No. 12. | Top floor, fourth (women's machine room). Same as No. 12. | 21,953 | 16 | 63 | 348 | – | 19 Mar. 1901, 3.10 p.m. | - ditto - | – | 3·2 | ditto | – | – | Four large roof windows and several side windows. all open. Hoist from below. | On entering the room found all windows closed, but women immediately opened them wide, with the result the air was pure, in spite of bad air entering from hoist well. |
| 20 | 19 March 1901 - | - ditto - ditto | 21,953 | 16 | 63 | 348 | – | 19 Mar. 1901, 3.20 p.m. | In front of hoist gate. | – | 8·2 | ditto | – | – | — | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 21 | - ditto - ditto | Third floor (L machine room). Same as No. 13. | 18,636 | 14 | 57 | 327 | – | 19 Mar. 1901, 3.30 p.m. | Body of room | – | 9·6 | ditto | – | – | Two fanlights, 6 ft. by 2 ft., open. Stairs and hoist above and below. | |
| 22 | Army tailoring, Pimlico, 23 Apl. 1901. | Ground floor (women's machine room). | 257,936 | 50 | 904 | 285 | – | 23 Apl. 1901, 2.50 p.m. | - ditto - | – | 4·6 | ditto | – | – | Sixteen large windows on each side, each open about four feet by three feet. Doors open. Enormous head space. | A fine, lofty, well-arranged building, kept very clean. The outside temperature was warm and the conditions dry and calm. Hence all windows open. |
| 23 | - ditto - ditto | First floor gallery (cutting out). | 179,010 | 13½ | 155 | 1,155 | – | 23 Apl. 1901, 3 p.m. | Middle of gallery. | W. 61 D. 75 | 4·6 | ditto | – | – | Good ventilation—similar to the above. | Same remarks apply. |
| 24 | - ditto - ditto | Second floor, top gallery (women's sewing room). | 187,180 | 14 | 490 | 382 | – | 23 Apl. 1901, 3.16 p.m. | - ditto - | 80 | 4·6 | ditto | – | – | Powerful centrifugal fan exhausting from gas pressing irons. Side windows, skylights and fanlights open. | This gallery was close under roof and the afternoon was exceedingly hot. |
| 25 | - ditto - ditto | - ditto - ditto | – | – | – | – | – | 23 Apl. 1901, 3.20 p.m. | Middle of gallery (more crowded side). | – | 4·6 | ditto | – | – | | |
| 26 | - ditto - ditto | First floor annexe (women's sewing room). | 86,496 | 12 | 150 | 596 | – | 23 Apl. 1901, 3.35 p.m. | Body of room | 78 | 4·2 | ditto | – | – | Sixteen large windows open on one side and three on other side. Twenty skylights open. | A long, narrow room recently added to main building. |
| 27 | Wholsale clothing. Swindon, 14 Mar. 1901. | Ground floor (women's machine room). | 99,300 | 25¼ | 151 | 651 | – | 14 Mar. 1901, 3.40 p.m. | - ditto - | – | 11·5 | ditto | – | – | Ventilators all closed. | A crowded-looking and stuffy-smelling building. This new portion was directly open to the old portion. There being no partition. |
| 28 | - ditto - ditto | First floor gallery (machine room). | 15,840 | 12 | 82 | 193 | – | 14 Mar. 1901, 3.50 p.m. | - ditto - | – | 11·0 | ditto | – | – | One hopper ventilator opened at time of visit, others closed. | This gallery forms a sort of bridge across the ground floor and is quite open at both sides to the over-head space of that portion of building. |
| 29 | Army Clothing Pimlico, 8 Oct. 1901. | Ground floor (women's sewing room.) | 257,936 | 50 | 860 | 300 | – | 8 Oct. 1901, 2.20 p.m. | Body of hall | 69 | 7·4 | ditto | – | – | One window open 4 ft. by 4 ft., others closed. Roof ventilators partly open. | Special re-visit to compare October results with those of April. The weather being much cooler now than then. |
| 30 | - ditto - ditto | - ditto - ditto | 257,936 | 50 | 830 | – | E.L. and gas, 176 jets. | 8 Oct. 1901, 6 p.m. | - ditto - | – | 7·4 | ditto | – | – | Five windows open and doors open from yard through which much air entered. | The results, generally, were not so good, although some windows appeared to have been opened just before Committee's entry. Heating steam shut off at 12 noon. |

APPENDIX I.—*continued.*

TABLE A.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 31 | Army Clothing, Pimlico, 8 Oct. 1901—*continued.* | 1st floor, west gallery (cutting shops). | 89,505 | 13½ | 43 | 2,081 | - | 8 Oct. 1901, 2.50 p.m. | Centre of gallery. | 67 | 7·6 | 3·5 (Estimate.) | - | - | Two windows open fairly wide, good current inwards. | Wind blew in through windows of west gallery across hall and could be felt in front of east gallery. No artificial heat on. Gas on ground floor explains higher result in evening. |
| 32 | - ditto - ditto | - ditto - ditto | 89,505 | 13½ | 4 | 22,000 | E.L., all on. | 8 Oct. 1901, 6.5 p.m. | Centre of gallery (3¼ hours later). | - | 10·0 | ditto | - | - | - ditto - ditto. | |
| 33 | - ditto - ditto | 1st floor, east gallery (cutting shop). | 89,505 | 13½ | 42 | 2,130 | - | 8 Oct. 1901, 3 p.m. | Centre of gallery. | 67 | 8·8 | ditto | - | - | No windows open this side. | *See* above. |
| 34 | - ditto - ditto | - ditto - ditto | 89,505 | 13½ | 42 | 2,130 | E.L., all on. | 8 Oct. 1901, 6.5 p.m. | Centre of gallery (3 hours later). | - | 10·0 | ditto | - | - | — | |
| 35 | - ditto - ditto | 2nd floor (top) east gallery (women's portion). | 94,340 | 14 | 99 | 953 | - | 8 Oct. 1901, 3.10 p.m. | Middle of gallery. | 69½ | 6·2 | ditto | - | - | Four windows open, good inward current. | The air current at windows was intermittent and occasionally reversed anemometer. Steam heater turned off. |
| 36 | - ditto - ditto | - ditto - ditto | 94,340 | 14 | 99 | 953 | - | 8 Oct. 1901, 3.20 p.m. | Near rail, gallery edge. | 69½ | 7·7 | ditto | - | - | — | |
| 37 | - ditto - ditto | - ditto - ditto | 94,340 | 14 | 89 | 1,060 | E.L. | 8 Oct. 1901, 6.20 p.m. | Near rail, gallery edge (3 hours later). | 73 (Estimate.) | 9·4 | ditto | - | - | Six windows and large skylight open. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 38 | - ditto - ditto | 2nd floor (top) west gallery (women's portion). | 92,820 | 14 | 300 | 309 | - | 8 Oct. 1901, 3.35 p.m. | Middle of gallery. | 71 | 7·7 | ditto | - | - | Eight windows open | Steam turned off. All rooms seemed very warm and comfortable. In part of this division was a row of 42 gas-heated irons, each well ventilated by a connected fan. |
| 39 | - ditto - ditto | - ditto - ditto | 92,820 | 14 | 285 | 325 | E.L. | 8 Oct. 1901, 6.15 p.m. | Middle of gallery ($2\frac{1}{2}$ hours later). | - | 8·0 | d tto | - | - | ... | |
| 40 | - ditto - ditto | - ditto - ditto | 92,820 | 14 | 300 | 309 | - | 8 Oct. 1901, 11.30 forenoon. | Middle of gallery (morning test). | 72 | 11·0 | ditto | - | - | Fifteen fanlights under eaves of middle roof partly open. | Test in morning gave higher results than either afternoon or evening owing to gas on ground floor. Steam on. |
| 41 | - ditto - ditto | 2nd floor of annexe (women's sewing room). | 86,496 | 12 | 324 | 267 | - | 8 Oct. 1901, 11.55 forenoon. | Near bench, at side. | 63 | 12·4 | ditto | - | | Windows and skylights all closed, doors shut automatically. | There appeared to be no kind of ventilation in operation, and the windows were streaming with moisture. Morning results high. No time for test in evening. |
| 42 | - ditto - ditto | - ditto - ditto | 86,496 | 12 | 324 | 267 | - | 8 Oct. 1901, 12 noon. | About middle (fairer test). | 63 | 11·0 | ditto | - | - | ... | |
| 43 | Wholesale clothing factory, Liverpool, 18 Jan. 1902. | 4th floor (top) (main machine room). | 33,008 | 16 | 100 | 330 | - | 18 Jan. 1901. 12.20 p.m. | End of room (breathing level). | - | 14·3 | 2·7 | - | | Circular ventilator and square louvre, both open. 24-in. extracting fan (stopped). | This was a top floor under roof of building. A good deal of cubic space was monopolised by a long gallery 10 ft. wide running nearly whole length down middle of room over workers' heads. Light and air was thus obscured. Gallery had but four occupants instead of being full as usual. Air seemed unwholesome. |
| 44 | - ditto - ditto | - ditto - ditto | 33,008 | 16 | 100 | 330 | - | 18 Jan. 1901, 12.30 p.m. | Body of room (under gallery). | - | 15·7 | 2·7 | - | - | - ditto - ditto - | |
| 45 | - ditto - ditto | - ditto - ditto | 33,008 | 16 | 100 | 330 | - | 18 Jan. 1901, 12.25 p.m. | In gallery over workers. | - | 17·4 | 2·7 | - | - | As above - - | |
| 46 | - ditto - ditto | 4th floor (top) (small machine room). | 17,500 | - | 48 | 364 | - | - ditto - | Body of room | - | 18·4 | 2·7 | - | | Top ventilator 18 in. by 18 in. (query open.) Louvred light. Door from stairs below open. | A better arranged room than the last, and air did not seem so bad as it proved to be. It should be noted in connection with the high results that the outside conditions were favourable, being clear and calm. |
| 47 | Wholesale stay factory, Gloucestershire, 15 Oct. 1901. | First floor (top) (machine room). | 32,319 | 15 | 63 | 513 | - | 15 Oct. 1901, 3.5 p.m. | - ditto - | - | 8·4 | 3·5 (Estimate.) | - | - | Three ridge cowls. No windows open. | Clean, light, and spacious room. Test made on very fine October day. |
| | Ditto - ditto | - ditto - ditto | 32,319 | 15 | 63 | 513 | - | 15 Oct. 1901, 3.8 p.m. | Nearer one side. | - | 7·8 | ditto | - | - | - ditto - ditto. | |

APPENDIX I.—*continued.*

TABLE A.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 48 | Wholesale stay factory, Gloucestershire, 15 Oct. 1901 (another firm). | Ground floor (machine room). | 71,400 | 21 | 158 | 452 | – | 15 Oct. 1901, 4.25 p.m. | Body of room | 17 | 18·9 | 3·5 (Estimate). | – | – | A large fan and overhead distributing tube provided for forcing in air (not working). Eight small Tobin's tubes for inlets. | A particularly nice-looking, clean, light, well-kept room, open to country on all sides. The results for first day were high, considering that no artificial light was being used, and the weather conditions fine. The mistake made was the common one of stopping the fan, except when required for heating and cooling purposes. A second, and almost exactly similar day, was selected for further tests, which proved this conclusively. The fan had been started in the morning for half-an-hour, and stopped as soon as the temperature became comfortable. Its utilisation for the purpose of ventilation only was thought unnecessary; the air therefore became vitiated, and remained so as long as the fan was stopped. Directly the fan was set at work the air became rapidly purer, and still more so when windows were opened as outlets. |
| 49 | - ditto - ditto | - ditto - ditto | 71,400 | 21 | 158 | 452 | – | 15 Oct. 1901, 4.28 p.m. | Body of room (another portion). | 17 | 16·3 | ditto | – | – | - ditto - ditto. | |
| 50 | Wholesale stay factory, Gloucestershire, 22 Oct. 1901. | - ditto - ditto | 71,400 | 21 | 128 | 560 | – | 15 Oct. 1901, 12.15 noon. | Body of room | – | 13·7 | ditto | – | – | Fan had blown in hot air, 8.a. m. to 8.30 a.m. and then stopped. Windows closed. Eight Tobin's tubes open. | |
| 51 | - ditto - ditto | - ditto - ditto | 71,400 | 21 | 158 | 452 | – | 22 Oct. 1901, 3 p.m. | - ditto - | – | 11·0 | ditto | – | – | Fan still stopped, and other vents, as above. | |
| 52 | - ditto - ditto | - ditto - ditto | 71,400 | 21 | 158 | 452 | – | 22 Oct. 1901, 3.20 p.m. | - ditto - | – | 5·5 | ditto | – | – | Fan had been working quarter of an hour, blowing in slightly warmed air. Windows and Tobin's tubes remaining closed. | |
| 53 | - ditto - ditto | - ditto - ditto | 71,400 | 21 | 158 | 452 | – | 22 Oct. 1901, 3.45 p.m. | - ditto - | – | 4·6 | ditto | – | – | Fan had been going 40 minutes, and five fanlights (each 24 in. by 30 in.) had been opened wide for outlets about 20 minutes. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 54 | Wholesale shirt factory, Somerset, 16 October 1901. | Second floor (machine room). | 24,802 | 10 | 103 | 240 | (20 gas irons). | 16 Oct. 1901, 12.43 noon. | Near gas irons. | – | 8·0 | ditto | – | – | Fifteen fanlights open at sides, cross ventilation. Clean. | Clean, well-kept room, and air seems good and wholesome. The space per person was 10 cubic feet under statutory limit. |
| 55 | - ditto - ditto | - ditto - ditto | 24,802 | 10 | 103 | 240 | (20 gas irons). | 16 Oct. 1901, 12.45 noon. | End of room | – | 9·6 | ditto | – | – | - ditto - ditto. | |
| 56 | Wholesale shirt factory, Somerset, 16 October 1901 (another firm). | First floor (top) (machine room). | 21,536 | 16 | 84 | 256 | – | 16 Oct. 1901, 3.40 p.m. | Body of room | – | 5·5 | ditto | – | – | Ten windows partly open at sides. | Clean, light, airy, and fresh-smelling room. |
| 57 | - ditto - ditto | Ground floor (finishing laundry). | 58,436 | 14 | 71 | 823 | (20 gas irons, &c.) | 16 Oct. 1901, 4 p.m. | - ditto - | – | 5·9 | ditto | – | – | Two 36-in. Blackman extracting fans. Four inlets at side remote from fans. | In all respects an apparently model room. Very clean well-kept room. Saw-back roof with north-light window. |
| 58 | Wholesale Collar Factory, Gloucester, 18 Feb. 1902. | Ground floor (ironing room). | 22,561 | 11 | 4 | 564 | Gas-heated machines. | 18 Feb. 1902, 2.50 p.m. | - ditto - | – | 19·6 | 5·0 | – | – | Two fanlights open at unoccupied end. | Clean, well-ordered room. Air appeared clear, but smelt gassy from irons and machines. The weather was calm, misty, and raw. |
| 59 | - ditto - ditto | - ditto - ditto | 22,561 | 11 | 40 | 564 | 18 jets alight. | 18 Feb. 1902, 5.18 p.m. | Body of room, (gas lit 10 minutes). | – | 13·0 | 4·6 | – | – | Eight fanlights open. | |
| 60 | - ditto - ditto | - ditto - ditto | 22,561 | 11 | 40 | 564 | 22 gas jets alight. | 18 Feb. 1902, 5.23 p.m. | Body of room, (gas lit 15 minntes). | – | 13·3 | 4·6 | – | – | As above. | |
| 61 | - ditto - ditto | First floor (women's machine room). | 59,602 | 15 | 90 | 662 | – | 18 Feb. 1902, 3.10 p.m. | Occupied side of room. | – | 37·0<br>36·0 | 5·0 | – | – | Ten fanlights slightly open. | Light, clean, spacious room, heated by steam-pipes, comfortably warm. The high results are difficult to account for, but probably the ventilators had all been closed to within a few minutes of a test being made, as women were seen to hurriedly open them. Not more than one-half the room was occupied, but the air was equally vitiated on the vacant side. |
| 62 | - ditto - ditto | - ditto - ditto | 59,602 | 15 | 90 | 662 | 52 gas jets. | 18 Feb. 1902, 5.25 p.m. | Occupied side of room (gas lit 5 minutes). | – | 37·8<br>38·6 | 4·6 | – | – | Twenty-two fanlights opened 1½ inches. One gable ventilator. | |
| 63 | - ditto - ditto | - ditto - ditto | 59,602 | 15 | 90 | 662 | 52 gas jets. | 18 Feb. 1902, 5.30 p.m. | Occupied side of room (gas lit 10 minutes). | – | 29·0<br>28·5 | 4·6 | – | – | As above. | |
| 64 | - ditto - ditto | - ditto - ditto | 59,602 | 15 | 90 | 662 | 52 gas jets. | 18 Feb. 1902, 5.28 p.m. | Unoccupied side of same room. | – | 34·8 | 4·6 | – | – | — | |

TABLE A—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| 1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 65 | Wholesale shirt factory, Gloucester, 18 Feb. 1902. | First floor (ironing room). | 13,221 | – | 20 | 661 | 18 gas (irons and machines). | 18 Feb. 1902, 4 p.m., daylight. | Body of room | 65 | 6·6 | 5·0 | – | – | Nine fanlights open fairly wide. | Clean, well ordered and ventilated room. Slight smell of gas irons. |
| 66 | - ditto - ditto | - ditto - ditto | 13,221 | – | 20 | 661 | 20 gas jets alight. | 18 Feb. 1902 5·40 p.m. | - ditto - | – | 8·0 | 4·6 | – | – | As above. | |
| 67 | - ditto - ditto | First floor (machine room). | 33,109 | 11 | 120 | 276 | – | 18 Feb. 1902, 3.30 p.m. | About centre | 61 | 23·5 | 5·0 | – | – | Four 14-in. patented ventilators in roof said to be open; other ventilators and windows closed. | Two rooms had been converted into one; clean, rather fully occupied, and comfortably warm. Steam-heated. Windows found closed in afternoon, and air smelt decidedly stuffy. The rooms were illuminated by "albocarbon" gas burners, which give a clear steady light, but not equal to incandescent burners. The jets were very numerous in proportion—107 jets to 120 occupants. Samples were taken near the floor and near the ceiling to compare with those at breathing level. |
| 68 | - ditto - ditto | ditto - ditto | 33,109 | 11 | 120 | 276 | 107 "albo" carbon gas jets. | 18 Feb. 1902, 5.45 p.m. | About centre (gas lit half an hour). | – | 12·5 | 4·6 | – | – | Nearly all windows dropped 1 or 2 inches from top, besides ventilators. | |
| 69 | - ditto - ditto | - ditto - ditto | 33,109 | 11 | 120 | 276 | ditto | 18 Feb. 1902, 6.18 p.m. | About centre (gas lit an hour). | 71 | 27·7 | 4·6 | – | – | All windows closed again for a quarter of an hour. Ventilators still open. | |
| 70 | - ditto - ditto | - ditto - ditto | 33,109 | 11 | 120 | 276 | ditto | 18 Feb. 1902, 6·25 p.m. | About centre, 18 inches above floor. | – | 22·2 | 4·6 | – | – | Windows had all just been dropped 1 to 2 inches. | |
| 71 | - ditto - ditto | - ditto - ditto | 33,109 | 11 | 120 | 276 | ditto | 18 Feb. 1902, 6.30 p.m. | About centre, 9 feet above floor. | – | 5·2 | 4.6 | – | – | Windows had been opened several minutes. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 72 | Wholesale shirt factory, Gloucester, 18 Feb. 1902. | First floor (machine room). | 33,109 | 11 | 120 | 276 | 107 "albocarbon" gas jets. | 18 Feb. 1902, 6.3 p.m. | *See* Remarks | – | 16·9 | 4·6 | – | – | Four 14-in. patented ventilators above. All windows dropped about 2 inches. | Of the two rooms that had been thrown together one was much smaller than the other, and these tests were made in the smaller. As the windows had evidently been opened on the rooms being approached they were ordered to be closed, so that samples could be taken with them both closed and open. It will be seen that the so-called ventilators had but little effect, but that the opening of windows made considerable difference. |
| 73 | - ditto - ditto | - ditto - ditto | 33,109 | 11 | 120 | 276 | ditto | 18 Feb. 1902, 6.8 p.m. | (Same place), 9 ft. above ground. | – | 20·2 | 4·6 | – | – | All windows had just been closed; ventilators still open. | |
| 74 | - ditto - ditto | - ditto - ditto | 33,109 | 11 | 120 | 276 | ditto | 18 Feb. 1902, 6.20 p.m. | Same at breathing level | – | 22·8 | 4·6 | – | – | Ventilators and one Tobin tube open; windows had been closed a quarter of an hour. | |
| 75 | Wholesale boot factory, Bristol 28 Nov. 1901. | Ground floor (Rounders' shop). | 23,345 | 14½ | 50 | 467 | Gas, 36 jets alight | 28 Nov. 1901, 6.30 p.m. | Body of room | – | 21·5 | 2·7 | – | – | Fan stopped. All ventilators closed. | Clean newly lime-washed workshop, very good of its kind, but air very hot and stuffy. Men had worked half-hour since tea-time with all ventilators closed. Other samples were taken in the same room after all the ventilating power had been applied 20 minutes, the effect of which is apparent in the results then obtained. |
| 76 | - ditto - ditto | - ditto - ditto | 23,345 | 14½ | 50 | 467 | ditto | 28 Nov. 1901, 7.20 p.m. | End near exhaust fan. | – | 6·0 | 2·7 | – | – | Two 24-in. fans set working, one exhausting and the other impelling air. Six trap-door ventilators in roof also opened. | |
| 77 | - ditto - ditto | - ditto - ditto | 23,345 | 14½ | 50 | 467 | Gas, 36 jets alight. | 28 Nov. 1901, 7.23 p.m. | End near inlet fan. | – | 6·0 | 2·7 | – | – | - ditto - ditto. | |
| 78 | - ditto - ditto | Ground floor (finishing shop). | 23,000 | 14 | 30 | 766 | Gas, 37 full jets. | 28 Nov. 1901, 6.55 p.m. | Body of room (not close to machines). | – | 9·2 | 2·7 | – | – | One 48-in. fan, extracting dust from row of machines, by means of duct. | The results in this room were good, considering the proportion of gas lights, 37 jets to 30 men. The dust-extracting arrangements appeared to serve very well for general ventilation also. The air was clear and good, and the shop very clean. |
| 79 | - ditto - ditto | - ditto - ditto | 23,300 | 14 | 30 | 766 | ditto | 28 Nov. 1901, 7.40 p.m. | Body of room (not close to machines), ¾ hour later. | – | 10·0 | 2·7 | – | – | — | |
| 80 | - ditto - ditto | First floor (girls' machine room). | 26,000 | 15 | 23 | 1,130 | Gas, 28 jets. | 28 Nov. 1901, 7.15 p.m. | Body of room (near sewing benches). | – | 17·0 | 2·7 | – | – | All ventilators and windows closed. | This was a large lofty room, very clean and thinly occupied. Ample provision for ventilation by windows and skylights (all closed). Air stuffy and impure. |
| 81 | Wholesale boot factory (another works), Gloucestershire, 15 Oct. 1901. | First floor, top (girls' machine room). | 4,050 | 9⅓ | 15 | 270 | – | 15 Oct. 1901, 3.55 p.m. | Body of room | – | 5·0 | 3·0 | – | – | One skylight slightly open. | Small dirty room in country factory. |

TABLE B.

TAILORING WORKSHOPS.—ENGLISH OCCUPANTS.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (82) | Tailoring workshops (English), London, W., 26 Jan. 1901. | Second floor | 7,750 | 9 | 17 | 456 | – | 26 Jan. 1901, 1.20 p.m. | Body of room | 61 | 7·0 | 3·5 (Estimate). | – | – | Sash window dropped 8 inches. Gas-iron heaters with flue. | Clean room, comfortably heated by small-bore steam pipes. |
| 2 (83) | ditto | ditto | Second floor (adjoining room). | 4,750 | 9 | 14 | 339 | – | 26 Jan. 1901, 1.30 p.m. | ditto | 64 | 12·8 | ditto | – | – | Sash window dropped 2 feet. | In the above case there was through communication to other rooms by doors constantly opened and shut. In this room there was a door only on one side, and the air was less pure. |
| 3 (84) | Tailoring workshop (English), London, E., 19 Mar. 1901. | First floor immediately over Jewish workshop, in same occupation. | 27,265 | 14 | 50 | 545 | 1 gas jet only. | 19 Mar. 1901, 4.15 p.m. | ditto | – | 14·6 | ditto | 10 | 2 | Three fall-back windows open. Skylights closed. | Cold inclement day. Long narrow room, fairly clean. Although only one gas jet alight, and ventilation similar to room below, the $CO_2$ was slightly higher. |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 (85) | Tailoring workshop (English), Cheltenham. 14 Feb. 1902. | First floor (men's tailoring). | 2,055 | – | 7 | 293 | 3 very large gas jets. | 14 Feb. 1902, 7.55 p.m. | Middle of platform (breathing level). | 72 | 16·5 | 4·3 | – | – | Window slightly open. Roof lantern with two louvred panes. | A fairly typical tailors' workroom (if anything above the average). Men sit on platform 18 inches above floor. Air hot, but seemed fairly fresh. A glass lantern 5 feet high on roof had louvred panes at each gable. Took sample of hot air emitted from one of these (*see* column No. 12). Gas was lit next morning to assist warmth in addition to fire, and had just been put out as we entered. |
| 5 (86) | - ditto - ditto | - ditto - ditto | 2,055 | – | 7 | 293 | Gas just put out. | 15 Feb. 1902, 11.25 a.m. | - ditto - | 63 | 15·6 | 3·4 | – | – | Fire chimney open. | |
| 6 (87) | - ditto - ditto | - ditto - ditto | 2,055 | – | 7 | 293 | 3 large gas jets. | 14 Feb. 1902, 8.10 p.m. | Outside louvre (*see* remarks). | – | 15·6 | 4·3 | – | – | — | |
| 7 (88) | - ditto - ditto | Third floor (men's room). | 1,800 | – | 4 | 450 | 3 gas jets 8 inches wide. | 14 Feb. 1902, 8.5 p.m. | 18 inches above platform. | 73 | 18·4 | 4·3 | – | – | Two sash windows dropped 5 inches. Coke stove with flue. | Very similar room to the above. Tailors sit on platform with large flaring gas jets on standards close beside them. Fairly clean. Air was hot, but seemed not bad. There were fewer hands and more ventilation at night than morning. |
| 8 (89) | Tailoring workshop (English), Cheltenham, 15 Feb. 1902. | - ditto - ditto | 1,800 | – | 7 | 286 | Gas just put out. | 15 Feb. 1902, 11.45 a.m. | - ditto - | 60 | 9·6 | 3·4 | – | – | Two windows dropped 1 inch. Stove as above. | |
| 9 (90) | Ladies' tailoring workshop (English), Cheltenham. 14 Feb. 1902. | First floor - - | 4 200 | – | 7 | 600 | 4 large gas jets and gas stove. | 14 Feb. 1902, 6.20 p.m. | Body of room | 60 | 17·6 | 4·3 | – | – | Two gas stoves with flues, with vents in chimneys, but no windows open, or other ventilation. | A newly erected clean room, not fully occupied, gas used to assist warming. Gas fireplace alight, but not on full. The outside conditions in Cheltenham were frost, and slight fog at night. Bright frosty air in morning. |
| 10 (91) | Tailoring workshop (English), Cheltenham, 14 Feb. 1902. | First floor, women machine room. | 1,570 | – | 5 | 314 | 4 large g a s jets. | 14 Feb. 1902, 7.30 p.m. | - ditto - | 72 | 53·2 | 4·3 | – | – | No ventilation, but chimney with fire lit. | A very unsatisfactory workroom. Scarcely clean and very untidy. Air decidedly stuffy and unwholesome. The worst place of its kind visited during the inquiry. |
| 11 (92) | - ditto - ditto | - ditto - ditto | 1,570 | – | 5 | 314 | – | 18 Feb. 1902, 12 noon. | - ditto - | – | 22·0 | 3·5 | – | – | As above. | |

TABLE C.

TAILORING WORKSHOPS.—JEWISH AND FOREIGN OCCUPANTS.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (93) | Tailoring workshop (foreign), London, E.C., 14 Feb. 1901. | Second floor (top) | 1,952 | 8 | 6 | 325 | 2 gas jets. | 14 Feb. 1901, 5.10 p.m. | Body of room | – | 12·0 | 3·5 (Estimate.) | – | – | Two sash windows slightly open. | Clear wintry day. Typical small tailor's workroom. Floor fairly clean, ceiling dirty. |
| 2 (94) | - ditto - ditto | - ditto - ditto | 1,952 | 8 | 6 | 325 | ditto | 14 Feb. 1901, 5.15 p.m. | - ditto - | – | 12·4 | ditto | – | – | — | |
| 3 (95) | Tailoring workshop (Jewish), London, E.C., 19 Mar. 1901. | Ground floor - | 26,460 | 14 | 50 | 529 | 17 gas jets, just lit. | 19 Mar. 1901, 3.50 p.m. | - ditto - | – | 14·6 | ditto | 25 | 3 | Several fall-back windows in walls not quite closed. | Cold rough day outside. Long, narrow, moderately clean room. Occupants all Jews (M. and F.). The second test half-an-hour later showed less $CO_2$ because of four windows open. |
| 4 (96) | - ditto - ditto | - ditto - ditto | 26,460 | 14 | 50 | 529 | 19 jets | 19 Mar. 1901, 4.20 p.m. | - ditto - (gas lit half hour). | – | 12·8 | ditto | – | – | Four windows fairly open. | |
| 5 (97) | Cap-makers' workshop (Jewish), London, E., 19 Mar. 1901. | Second floor - (Blocking shop.) | 1,712 | 8 | 6 | 285 | – | 19 Mar. 1901, 4.50 p.m. | Body of room | – | 8·8 | ditto | Lost | Lost | One window half-open; gas heater with flue. | Cold day. Rooms not very clean. Occupants all foreign Jews. |
| 6 (98) | - ditto - ditto | Third floor (top) - (Machine room.) | 4,296 | 8 | 18 | 238 | - | 19 Mar. 1901, 5 p.m. | - ditto - | – | 23·0 | ditto | 9 | 2 | Practically none. Occupier forced open one or two windows as we entered. | Eighteen foreigners present during test. This was the highest result in daylight for any Jewish place we visited. |
| 7 (99) | Tailoring workshop (Jewish), Whitechapel, 20 Mar. 1901. | Third floor - - | 2,850 | 9 | 8 | 356 | | 20 Mar. 1901, 12.5 noon. | - ditto - | – | 6·0 | ditto | – | – | Gas heater and flue (open); windows closed. | The following tests were taken in a block of typical East-end Jewish workshops on a very cold windy day. Clean room adjoining living apartment. |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 (100) | - ditto - ditto (Another occupier.) | Fourth floor - | 2,500 | 9 | 6 | 416 | – | 20 Mar. 1901, 12.30 p.m. | - ditto - | – | 12·8 | ditto | 5 | 0 | One flue open and windows closed (fairly tight fitting). | Moderately clean room. Not many chinks for ventilation as in some other rooms. |
| 9 (101) | - ditto - ditto (Another occupier). | Second floor - | 3,250 | 10 | 10 | 325 | – | 20 Mar. 1901, 12.40 p.m. | - ditto - | – | 6·4 | ditto | Lost | Lost | One sash window dropped 3 inches, flue open. | Fairly clean room, adjoining dwelling-room. |
| 10 (102) | - ditto - ditto (Another occupier.) | Ground floor - | 3,695 | 10 | 13 | 284 | – | 20 Mar. 1901, 12.50 p.m. | - ditto - | – | 9·6 | ditto | Lost | Lost | One sash window dropped 3 inches, gas heater flue open. | Room rather dirty; walls, ceiling and floor wanted cleaning. |
| 11 (103) | - ditto - ditto (Another occupier.) | Third floor - | 2,750 | 9 | 8 | 344 | – | 20 Mar. 1901, 2.20 p.m. (just after dinner). | - ditto - | – | 4·6 | ditto | 16 | 2 | Door and one air grid open; coke stove with flue. | Rather dirty room adjoining dwelling. |
| 12 (104) | - ditto - ditto (Another occupier.) | Second floor - | 2,907 | 9 | 7 | 415 | – | 20 Mar. 1901, 2.30 p.m. | - ditto - | – | 6·8 | ditto | 5 | 2 | Door open, coke stove with flue. | Moderately clean room adjoining dwelling. |
| 13 (105) | - ditto - ditto (Another occupier.) | First floor - - | 2,907 | 9 | 9 | 323 | – | 20 Mar. 1901, 2.40 p.m. | - ditto - | – | 8·2 | ditto | Lost | Lost | As above, and two air grids open. | Rather dirty, rags about, adjoins dwelling. |
| 14 (106) | - ditto - ditto (Another occupier.) | Ground floor - | 2,500 | 10 | 5 | 500 | – | 20 Mar. 1901, 3 p.m. | - ditto - | – | 7·4 | ditto | Lost | Lost | One window open; gas heater and flue. | Fairly clean room. |
| 15 (107) | - ditto - ditto Cap maker. | Fourth floor (top) | 3,024 | 9 | 6 | 504 | – | 20 Mar. 1901, 12.20 p.m. | - ditto - | – | 4·6 | ditto | 2 | 5 | No ventilation except through chinks; windows very draughty. | Not very clean room; lots of rags and cuttings about. |

APPENDIX I.—*continued.*

TABLE D.

WORKSHOPS.—DRESSMAKING, MILLINERY, UNDERCLOTHING, &c.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volume of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (1.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (108) | Underclothing workshop, London, E.C., 11 Jan. 1901. | Fifth floor (top), women's machine room. | 13,301 | 11⅔ | 24 | 554 | 9 gas jets, | 11 Jan. 1901, 4.45 p.m. | Body of room | 70½ | 7·8 | 5·0 | – | – | Air inlets both ends and skylight open. Two gas stoves with flues. | Clean, well kept room. Air seemed wholesome and comfortable Results very good considering fog outside. |
| 2 (109) | Furriers' workshop, London, E.C., 14 Jan. 1901. | Fifth floor (top), small attic (swansdown room). | 3,145 | 9⅓ | 7 | 449 | 4 gas jets. | 14 Jan. 1901, 1.0 p.m. | - ditto - | – | 21·0 | 3·5 | – | – | Windows all closed until we entered room. | Clean workroom. The high reading of $CO_2$ was probably due to gas being lit for warming purposes, there being no other means. Impure air may also have found its way up the stair from rooms below. |
| 3 (110) | Dressmaking workroom, London, W., 26 Jan. 1901. | Ground floor (sewing room). | 3,258 | 9½ | 13 | 250 | – | 26 Jan. 1901, 12.5 noon. | - ditto - | – | 9·6 | 3·5 (Estimate). | – | – | One sash window dropped 4 inches. Two fire-places open, but no fire. | Clean but cold room. |
| 4 (111) | - ditto - ditto (Another occupier.) | Small detached building, glazed roof; built for studio. | 3,704 | 9½ | 9 | 411 | – | 26 Jan. 1901, 12.25 p.m. | - ditto - | – | 8·7 | 3·5 | – | – | Small coke stove alight, with flue and small hole in roof. | Clean, light room. Glazed roof not air-tight. |
| 5 (112) | - ditto - ditto (Another occupier.) | Fourth floor (skirt room). | 14,250 | 14 | 35 | 407 | E.L. | 26 Jan. 1901, 12.50 p.m. | - ditto - | 61½ | 7·2 | 3·5 (Estimate). | – | – | Three sash windows dropped 7 inches. Two small gratings open. | Clean, wholesome workroom. Heated by small-bore steam pipes. One of a series of rooms in large West-end establishments, others of |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 (113) | - ditto - ditto | Fourth floor (bodice room). | 6,250 | 10 | 25 | 250 | – | 26 Jan. 1901, 1.0 p.m. | - ditto - | 58½ | 9·4 | ditto | – | – | Two sash windows dropped 15 inches. | which follow. They were all illuminated by E.L. after dusk, but the tests were only made at mid-day. The $CO_2$ was reasonably low, and the air seemed fresh and healthy. |
| 7 (114) | - ditto - ditto | Third floor (mantle room). | 11,250 | 14 | 27 | 416 | – | 26 Jan. 1901. 1.5 p.m. | - ditto - | – | 5·0 | ditto | – | – | One side window open. Three pivoted windows in skylights, each open about 30 inches by 15 inches. | |
| 8 (115) | - ditto - ditto | Second floor (skirt room). | 10,750 | 9 | 27 | 398 | – | 26 Jan. 1901, 1.10 p.m. | - ditto - | 62½ | 9·2 | ditto | – | – | Two sash windows dropped 12 inches. | |
| 9 (116) | - ditto - ditto | Second floor (general dressmaking). | 9,000 | 11 | 27 | 333 | – | 26 Jan. 1901, 1.45 p.m. | At one crowded corner. | 63 | 12·6 | ditto | – | – | Two sash windows dropped about 8 inches. One fireplace. | This was a long narrow room about 70 ft. by 12 ft., with windows all along one side, and door on opposite side. It was a bright clean room and the air seemed quite fresh on entering; but the $CO_2$ proved higher than expected, especially in corner where there was no current. |
| 10 (117) | - ditto - ditto | Second floor - | 9,000 | 11 | 27 | 333 | – | 20 Jan. 1901, 1.48 p.m. | Opposite door and near window. | 62 | 9·2 | ditto | – | – | Fire not lit. | |
| 11 (118) | Dressmaking workshop, London, W., 16 Feb. 1901. | Ground floor (mantle room). | 21,600 | 13 | 60 | 360 | 3 gas jets. | 16 Feb. 1901, 12.30 p.m. | Body of room | – | 13·2 | 3·5 (Estimate). | 8 | – | One front window open. Skylight with one middle swing window open 4 inches. | This was another series of workrooms in a West-end establishment, referred to the Committee as being specially good. The results however were generally high. The outside air was still, though cold and fine. The rooms were heated by steam, which was not fully on. |
| 12 (119) | - ditto - ditto | Third floor (top) (blouse room). | 8,250 | 8½ | 32 | 258 | ditto | 16 Feb. 1901, 12.50 p.m. | - ditto - | 58 | 20·2 | ditto | 7 | – | Four windows dropped about 3 inches. | |
| 13 (120) | - ditto - ditto | Second floor (dress room). | 8,190 | 9 | 28 | 318 | ditto | 16 Feb. 1901, 1.8 p.m. | - ditto - | – | 26·6 | ditto | 9 | – | Seven windows barely opened, about 1 inch. Chimney flue, no fire. | The women were just leaving when this room was first tested, and much dust was disturbed in "clearing up." |
| 14 (121) | - ditto - ditto | - ditto - ditto | 8,190 | 9 | 28 | 318 | ditto | 16 Feb. 1901, 1.18 p.m. | - ditto - | – | 18·4 | ditto | – | – | — | The second test was made some 10 or 15 minutes after most had gone. There was no communication between upper rooms and those below, the stair door being kept shut. This room had a generally clean appearance. |

APPENDIX I.—*continued.*

TABLE D—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 15 (122) | Dressmaking workshop, London, W. (Another occupier, 22 Feb. 1901.) | Ground floor (back) (skirt room). | 3,000 | 12 | 10 | 300 | 8 gas jets, 2 iron stoves. | 22 Feb. 1901. 12 noon. | Body of room | 62 | 20·2 | 3·5 | 4 | 2 | Windows closed. Two chimneys open, with one small air grid over mantel. | This workroom was specially referred to Committee as one in which the air was deteriorated by the use of gas jets for warming purposes. The gas had just been put out as we entered, the burners being still warm. A smell of incompletely burnt gas was noticed, probably proceeded from gas stoves used for irons. Fairly clean room, walls painted, floors scrubbed. |
| 16 (123) | - ditto - ditto | First floor (back) (bodice room). | 3,500 | 10 | 12 | 292 | 6 gas jets, 1 stove. | 22 Feb. 1901 12.20 p.m. | - ditto - | 60 | 14·6 | ditto | 6 | 1 | One chimney with small grid over mantel. Windows closed. One gas stove with flue. | Moderately clean room, walls painted, ceiling limewashed, floors scrubbed. No perceptible smell from gas. |
| 17 (124) | Dressmaking workroom, Cheltenham, 14 and 15 Feb. 1902. | First floor (dress room). | 4,500 | – | 13 | 346 | 6 large gas jets | 14 Feb. 1902, 6 p.m. | - ditto - | 59 | 19·6 | 4·3 | – | – | Chimney with fire lit. Skylights closed. | A moderately clean workroom. Inadequately warmed by fire. Temperature 59° by gaslight, and 50° next morning, when gas burners had just been lit at 9.50 a.m. to assist warmth. |
| 18 (125) | - ditto - ditto | - ditto - ditto | 4,500 | – | 13 | 346 | 6 jets, just lit. | 15 Feb. 1902, 9.50 a.m. | - ditto - | 50 | 12·0 | 3·4 | – | – | Fire lit, and two small windows slightly open near roof. | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 19 (126) | - ditto - ditto | First floor (mantle room). | 2,310 | – | 6 | 385 | 3 large gas jets. | 14 Feb. 1902, 6.5 p.m. | - ditto - | 64 | 12·0 | 4·3 | – | – | Fire grate (fire lit) and one small pane ventilator. | Moderately clean workroom, warmed by fire, but temperature at 9.40 in the morning was under 60°, although two gas jets were lit in addition to fire. |
| 20 (127) | ditto - ditto | - ditto - ditto | 2,310 | – | 6 | 385 | 2 gas jets. | 15 Feb. 1902, 9.40 a.m. | - ditto - | 59 | { 21·2 / 20·0 } | 3·4 | – | – | As above. | |
| 21 (128) | - ditto - ditto (Another occupier), 14 and 15 Feb. 1902. | First floor (millinery room). | 2,736 | – | 8 | 342 | 5 E.L. lamps. | 14 Feb. 1902, 6.30 p.m. | - ditto - | 55 | 8·2 | 4·3 | – | – | No ventilators open except flue over gas stove for irons. | A clean workroom, air clear and seemed wholesome. Heated by steam on two sides of room, but temperature rather low at both tests. The occupants said that they kept the E.L. alight in day time as they thought it was warmer. It should be noticed that the weather was frosty and slightly foggy. |
| 22 (129) | - ditto - ditto | - ditto - ditto | 7,560 | – | 7 | 391 | 5 E.L. lamps. | 15 Feb. 1902, 10.35 a.m. | - ditto - | 55 | 7·6 | 3·4 | – | – | As above - - | |
| 23 (130) | - ditto - ditto | First floor (dressmaking room). | 7,560 | – | 13 | 581 | 9 E.L. lamps. | 14 Feb. 1902, 6.43 p.m. | - ditto - | 62 | 12·0 | 4·3 | – | – | Gas heater with flue open. One window dropped 1 inch. | Clean workroom, heated by high-pressure steam pipes, but found to be rather cold in morning (51° at 10.15 a.m.). The excess of $CO_2$ in morning as compared with night is probably accounted for by the decrease in temperature and non-opening of windows. |
| 24 (131) | - ditto - ditto | - ditto - ditto | 7,560 | – | 13 | 581 | 9 E.L. lamps. | 15 Feb. 1902, 10.15 a.m. | - ditto - | 51 | 13·6 | 3·4 | – | – | No ventilation at all except flue. | |
| 25 (132) | - ditto - ditto | Second floor (skirt making). | 7,380 | – | 22 | 335 | 12 E.L. lamps. | 14 Feb. 1902, 6.48 p.m. | - ditto - | 61 | 11·2 | 4·3 | – | – | One window dropped 6 inches, gas stove for irons with flue. | Fairly clean workroom, heated by high-pressure steam, of which this room seemed to get more than its share. The forewoman complaining of heat in one corner. |
| 26 (133) | - ditto - ditto | - ditto - ditto | 7,380 | – | 22 | 335 | 12 E.L. lamps. | 15 Feb. 1902, 10.25 a.m. | - ditto - | 61 | 13·8 | 3·4 | – | – | Five windows dropped 2 inches each. | |
| 27 (134) | - ditto - ditto | Ground floor (millinery room). | 3,943 | – | 15 | 263 | 12 E.L. lamps. | 14 Feb. 1902, 6.55 p.m. | - ditto - | 62 | 13·5 | 4·3 | – | – | Two end windows dropped 6 inches. | Another fresh, clean-looking workroom of same series. Steam pipes on two sides. Windows possibly opened on our approach. |
| 28 (135) | - ditto - ditto | - ditto - ditto | 3,943 | – | 14 | 282 | 12 E.L. lamps. | 15 Feb. 1902, 10.30 a.m. | - ditto - | 58 | 10·4 | 3·4 | – | – | One window dropped 12 inches at opposite end from last night, others closed. | |

TABLE E.

BOOT WORKSHOPS.—ENGLISH AND JEWISH OCCUPANTS.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (136) | Boot workshops, Whitechapel, 19 Mar. 1901. | Third floor (top) (finishing room). | 9,990 | 13½ | 22 | 459 | Gas (6 rose burners for irons). | 19 Mar. 1901, 5.25 p.m. | Body of room | – | 15·6 | 3·5 (Estimate). | Lost | Lost | Three side windows open 14 inches. Two stairs from below. Skylights closed. | Clean room, only occupied four months. Painted walls. All Jewish occupants. |
| 2 (137) | - ditto - ditto | First floor (clicking room). | 10,412 | 14 | 15 | 694 | Gas, 15 jets. | 19 Mar. 1901, 5.40 p.m. | - ditto - | – | 16·5 | - ditto | Lost | Lost | One side window slightly open. One stair above and below. | Fairly clean room. All male Jews. High result probably due to gas. |
| 3 (138) | - ditto - ditto | Basement (rough-stuff room). | 8,688 | 9 | 15 | 579 | Gas, 9 jets. | 19 Mar. 1901, 5.55 p.m. | - ditto - | – | 8.8 | - ditto | 25 | 6 | One stair open to room above. Windows all closed. | Clean, limewashed walls. |
| 4 (139) | Boot workshop, Gloucestershire, 17 Dec. 1901. | Ground floor (annexe) (women's machine room). | 3,212 | 7⅝ | 28 | 117 | Oil, 8 lamps. | 19 Dec. 1901, 4.30 p.m. | Near door (6 feet away). | – | 34·0 | 3·0 | – | – | No ventilation open anywhere except unhinged door at one extremity of L shaped room, and coke stove with flue. Windows all closed. Papers placed under roof to prevent draught from crevices. | An overcrowded, little wooden shanty surrounding two sides of main factory, with very low lean-to roof (av. height under 8 feet) Brick floor; wooden roof; glass sides, and 8 windows with small fanlights 3 feet by 1 foot all closed. If machines, boxes, and other obstructions were taken into |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 (140) | - ditto - ditto | - ditto - ditto | 3,212 | 7⅝ | 28 | 117 | Oil, 8 lamps. | 17 Dec. 1901, 4.33 p.m. | In angle of L shaped room. | – | 27·2 | 3·0 | – | – | - - ditto. | account the cubic space would have been less than 100 cubic feet, per person. Room occupied since 6.30 a.m. except breakfast 8 to 8.30 and dinner 1 to 2. The paraffin lamps were 2 of 100 candle power, 6 of 50 candle power, and 2 of 10 candle power. They had been lit half an hour when first round of tests were made, and an hour and a quarter before second round. Air hot and obviously bad. It will be seen that the $CO_2$ was higher nearest the door, that being the chief outlet for the impurities. Outside conditions, slight breeze, then threatening rain. |
| 6 (141) | - ditto - ditto | - ditto - ditto | 3,212 | 7⅝ | 28 | 117 | Oil, 8 lamps. | 17 Dec. 1901, 4.36 p.m. | Extremity of room farthest from door. | – | 23·2 | 3·0 | – | – | - - ditto. | |
| 7 (142) | - ditto - ditto | - ditto - ditto | 3,212 | 7⅝ | 26 | 123 | Oil, 8 lamps. | 17 Dec. 1901, 5.15 p.m. | Same position as at 4.30 | – | 18·8 | 3·0 | – | – | - - ditto. | |
| 8 (143) | - ditto - ditto | - ditto - ditto | 3,212 | 7⅝ | 26 | 123 | Oil, 8 lamps. | 17 Dec. 1901, 5.18 p.m. | Same position as at 4.33. | – | 11·0 | 3·0 | – | – | - - ditto. | |
| 9 (144) | - ditto - ditto | - ditto - ditto | 3,212 | 7⅝ | 26 | 123 | Oil, 8 lamps. | 17 Dec 1901, 5.23 p.m. | Same position as at 4.36. | – | 13·8 | 3·0 | – | – | - - ditto. | |
| 10 (145) | Boot workshop, Gloucestershire, 17 Dec. 1901. (Another Occupier.) | Ground floor (rounders' workshop). | 1,440 | 9 | 6 | 240 | Oil, 6 lamps. | 17 Dec. 1901, 6.15 p.m. | Body of room | – | 23·4 | 3·0 | – | – | No ventilation at all and everything closed up. | A stuffy little place with less than the statutory 250 cubic feet per person. Dark, dingy, wretched; smell of oil. Rough earth floor, very dirty. Air stagnant and obviously foul. As the first workshop in this table was in crowded Whitechapel and the last two in the open country, it is interesting to observe how much worse were the conditions in the latter places. The occupants were Jews in the first case and English in the others. |

TABLE F.

LAUNDRIES.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (146) | Factory laundry, London, N.W., 19 April 1901. | First floor (ironing room). | Not taken but ample. | – | 40 | – | 2 gas-heated machines. | 19 April 1901, 11.25 a.m. | Body of room | See remark. | 3·6 | 3·5 (Estimate.) | – | – | Large, side windows with 11 fanlights open. One louvred ventilator open in roof. Large coke stove with flue. One 36-inch extracting fan. | Large, airy rooms, referred to this Committee as specially good. Glazed brick walls. Iron roofs. Room very warm, but air fresh. Very hot, sunny day. Outside temperature abnormally high (76 degrees in shade). Inside temperature near door of stove room 90 degrees. In body of room, Dry 80–81; Wet 64–65. |
| 2 (147) | - ditto - ditto | Ground floor (wash-house). | ditto | – | 5 | – | – | 19 April 1901, 11.40 a.m. | - ditto - | ditto | 3·6 | ditto | – | – | One 48-inch extracting fan over coppers. Two doors open. Windows closed. | Large, lofty room, glazed brick walls. Air clear of steam. Temperatures, Dry 74–72; Wet 62–58. |
| 3 (148) | Another factory laundry, London, N.W., 19 April 1901. | Second floor (top) ironing room. | 5,910 | 10 | 14 | 422 | – | 19 April 1901, 12.2 p.m. | - ditto - | ditto | Not taken. | ditto | – | – | Six large windows on one side, each open. Stairs and hoist below. | This laundry was referred to Committee as unsatisfactory presumably on account of the excessive heat. Temperature near stove 86–90 degrees. Hygrometer in centre, 82·0 Dry; 70·5 Wet. Although warm, the air was obviously fresh and no test taken. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 (149) | - ditto - ditto | First floor (calender room). | 11,340 | 12½ | 20 | 567 | – | 19 April 1901, 12.40 p.m. | - ditto - | ditto | 3·5 | ditto | – | – | One 24-inch fan short - circuiting near open window. Seven large windows on one side each open 6 inches by 2. Stairs and hoist above and below. | A long, narrow room with brick limewashed walls, and windows all on one side. Exceedingly hot. The temperature and moisture varied considerably at different parts of room, according to height and position, currents of air and proximity to calenders. The following readings were taken about 5 feet from the ground, Dr. Haldane, Dry 88–86–88; Wet 72–74–75; Mr. Osborn, Dry 85–86; Wet 74–78.<br>The ventilation could probably be improved and the temperature reduced by judicious use of existing fan power, now wasted by short circuiting. |
| 5 (150) | - ditto - ditto | Ground floor (wash-house). | 7,885 | 14 | 4 | 1,971 | – | 19 April 1901, 12.50 p.m. | - ditto | ditto | Not taken. | ditto | – | – | One 30-inch fan. Action restricted by outlets. Three windows and two doors open. Stairs and lift above. | Whitewashed brick walls, air hot but fairly fresh and free from steam. Temperature, Dry 86·5; Wet 73·0. Here again a powerful fan was wasted by the restrictions on its output, there being three sharp square turns in the chimney which served as upcast. |
| 6 (151) | Factory laundry, London, S.W., 23 April 1901. | - ditto - ditto | – | – | – | – | – | 23 April 1901, 4.30 p.m. | — | D. 89 W. 77 | – | – | – | – | One 48-inch fan; action restricted by insufficient outlet, and also short circuiting from three large fanlights over washing machines. | Referred to the Committee as unsatisfactory, which it undoubtedly was from the excessive heat in calender room and excessive steam in wash-house. The large fan in calender room drew its supply of cold air through the windows over washing machines. The inrush of cold air thus increasing the condensation of steam, which was being drawn across the room instead of being forced out of the wash-house. The weather was abnormally hot (76 degrees in shade) but the air inside was fairly fresh and was not sampled. |

TABLE F.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 7 (152) | Factory laundry (another occupier), London, W., 15 April 1902. | First floor (ironing room), "No. 3." | 68,034 | – | 33 | 2,061 | – | 15 Apr. 1902, 11.55 a.m. | Centre of room. | – | 7·4 | 3·7 | – | – | In centre of room a 48-inch Blackman fan in trunk passing from room below to roof in room above. Also three-tier swivelled windows, of which four on one side and three on opposite side—apparently open all day. | Outside conditions — mild, occasional drizzle; little wind. Gas irons, into which air is forced; this regulated by the workers; evidently leakages as the smell of gas is very perceptible, and had not disappeared by the end of the dinner time (12 to 1). |
| 8 (153) | - ditto - ditto | - ditto - ditto | 68,034 | – | 33 | 2,061 | – | 15 Apr. 1902, 12 noon. | — | – | 7·2 | 3·7 | – | – | | |
| 9 (154) | - ditto - ditto | - ditto - ditto | 68,034 | – | 33 | 2,061 | – | 15 Apr. 1902, 1.15 p.m. | — | – | 6·1 | 3·7 | – | – | | |
| 10 (155) | - ditto - ditto | - ditto - ditto | 68,034 | – | 33 | 2,061 | – | 15 Apr. 1902, 1.20 p.m. | — | – | 7·4 | 3·7 | – | – | | |
| 11 (156) | - ditto - ditto | Ground floor (sorting room). | 22,055 | – | 12 | 1,857 | – | 15 Apr. 1902, 1.30 p.m. | — | – | 5·1 | 3·7 | – | – | Partitioned off from another room, but none of its windows open. | The partition is about seven feet high, but as none of the windows were open in the sorting department, but were so in the other part of the room (as in the room above which is ventilated as No. 3), the air here appeared to be stagnant. |
| 12 (157) | Workshop laundry, Sheffield, 30 Jan. 1901. | Ground floor - | – | – | 2 | 384 | – | 30 Jan. 1901, 2.20 p.m. | — | 38·2 (outside) Barometer 29·332 | 8·2 | Not recorded. | – | – | Fire lit, and window open. | For the figures and results given for this small laundry the Committee are indebted to Dr. Robertson, Medical Officer of Health for Sheffield. |
| 13 (158) | - ditto - ditto | First floor (back) | – | – | 4 | 740 | – | 30 Jan. 1901, 2.25 p.m. | — | ditto - | 8·2 | ditto - | – | – | No fire; window and one grating open. | |
| 14 (159) | - ditto - ditto | - ditto - ditto | – | – | 4 | 956 | – | 30 Jan. 1901, 2.50 p.m. | — | ditto - | 7·4 | ditto - | – | – | No fire; window open. | |

TABLE G.

CABINET AND UPHOLSTERY WORKS.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | 2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (160) | Wholesale cabinet works, London, W.C., 15 Jan. 1901. | Fourth floor (upholstery department). | 25,088 | 8 | 44 | 570 | Gas, 35 jets. | 15 Jan. 1901, 4.50 p.m. | Body of room | 62 | 15·6 | 3·5 (Estimate). | – | – | Two whirling extractor ventilators with cowl outside roof and circular uptake 15 ins. dia. Each extracting about 600 c.f. per minute. Windows closed. | One of a series of wookrooms in a large establishment. Fairly clean, and well kept. |
| 2 (162) | - ditto - ditto | - ditto - ditto | 25,088 | 8 | 44 | 570 | Gas, 35 jets. | 15 Jan. 1901, 4.55 p.m. | - ditto - | 62 | 15·1 | ditto | – | – | | |
| 3 (163) | - ditto - ditto | Fourth floor (upholstery room, adjoining above). | 43,231 | 10½ | 70 | 618 | Gas, 41 jets. | 15 Jan. 1901, 5 p.m. | - ditto - | 69 | 20·2 | ditto | – | – | Eighteen small air grids 8 in. by 8 in. placed round walls near ceiling. | This was a much larger room adjoining the last. Fairly clean, and well kept. High reading of $CO_2$ probably due to gas. Outside conditions unfavourable. |
| 4 (164) | Upholsterers' workshop, London, W., 15 Jan. 1901. | Fifth floor, top (fringespinning). | 18,000 | 12 | 10 | 1,800 | Gas, 9 jets. | 15 Jan. 1901, 5.45 p.m. | - ditto - | – | 20·2 | ditto | – | – | No ventilation, windows all closed. | A fairly clean and spacious workroom, on top floor, with occupied rooms below. |
| 5 (165) | - ditto - ditto | - ditto - ditto | 18,000 | 12 | 10 | 1,800 | Gas, 9 jets. | 15 Jan. 1901, 5.50 p.m. | - ditto - | – | 20·7 | ditto | – | – | | |
| 6 (167) | - ditto - ditto | - ditto - ditto | 18,000 | 12 | 10 | 1,800 | Gas, 9 jets. | 15 Jan. 1901, 5.55 p.m. | At top of stairs, just outside room. | – | 7·4 | ditto | – | – | | |
| 7 (168) | Railway carriage works, Wiltshire. 14 March, 1901. | Ground floor (women's upholstery shop). | 62,128 | 24¼ | 40 | 1,553 | – | 14 March 1901, 2.40 p.m. | Body of room | – | 6·8 | ditto | – | – | One ridge ventilator very slightly open. Windows closed. | Clean, spacious, and lofty room. |
| 8 (169) | - ditto - ditto | Ground floor (carriage finishing and cabinet department). | 289,275 | 23¾ | 260 | 1,112 | – | 14 March 1901, 3.20 p.m. | - ditto - | – | 6·8 | ditto | – | – | Same as above. | Same as above. |
| 9 (170) | - ditto - ditto | Ground floor (horsehair carding). | 93,786 | 20½ | 9 | 10,415 | – | 14 March 1901, 3.10 p.m. | - ditto - | – | 4·6 | ditto | 10<br>10 | 2<br>– | A 30-in. extracting fan and another fan connected to carding machines in full work. One large side window open. | This was at one time the most dusty place in the works, but the extracting arrangements are now very good and scarcely any dust is to be seen. Clean, spacious, well lighted, and newly limewashed building. |

APPENDIX I.—*continued.*

TABLE H.

BREAD, CONFECTIONERY, AND ARTICLES OF FOOD, &c.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volume of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (171) | Wholesale chocolate factory, Bermondsey, 21 Feb. 1901. | Basement (chocolate mixing). | 12,000 | 8½ | 20 | 600 | Gas, 9 jets. | 21 Feb. 1901, 5.25 p.m. | Body of room | – | 6·2 | 3·5 (Estimate). | 8 | – | Three air inlets at pavement level, with strong inward current. Stair to room above. | Referred to the Committee as very unsatisfactory. All the woodwork was varnished, but the floors were thick with trodden-in chocolate, &c., and it was otherwise an unclean-looking place. A considerable part of room was occupied by a refrigerating chamber and apparatus. |
| 2 (172) | - ditto ditto | First floor (packing room). | 23,760 | 9 | 30 | 792 | Gas, 10 jets. | 21 Feb. 1901, 5.40 p.m. | - ditto - | – | 4·6 | ditto - | – | – | Hoist and stairs above and below. Side windows and air grids closed. | A roomier and cleaner apartment than that below. |
| 3 (173) | Wholesale factory bakehouse, Wiltshire, 14 Mar. 1901. | Ground floor - | 15,200 | 10 | 10 | 1,520 | Gas, 3 jets, 2 ovens. | 14 Mar. 1901, 11 a.m. | - ditto - | – | 6·0 | ditto - | 2 | – | Three large side windows with two hopper panes open. Three doors open and stairs to loft. | A very clean and satisfactory bakehouse in every way; glazed brick wall and concrete floors. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 (174) | Wholesale condensed milk factory, Bucks., 24 Apr. 1901. | Ground floor (box making). | Not taken. Enormous. | – | – | – | – | 24 Apr. 1901, 12.0 noon. | - ditto - | – | 3·2 | 3·2 | 0·5 | 0 | Three extracting propeller fans, one centrifugal impelling fan; windows on every side. | A very large and thinly occupied room, with an amount of ventilation which rendered the air as pure as outside. |
| 5 (175) | Wholesale chocolate factory, London, S.E., 10 Oct. 1901. | Ground floor (chocolate covering room). | 58,368 | 16 | 153 | 381 | E.L. | 10 Oct. 1901, 3.35 p.m. | About 20 feet from door. | 69 | 5·2 | 3·0 | – | – | Two 30-inch extractor fans, one at each end. Six inlets at base of columns, 28 roof ventilators 7 inches diameter. | A particularly clean wholesome room with drawback roof and north light, in a well appointed and most modern factory. The air was very pure and pointed to a successful system of mechanical ventilation, which was not however in full working order. |
| 6 (176) | - ditto - ditto | - ditto - ditto | 58,368 | 16 | 153 | 381 | E.L. | 10 Oct. 1901. 3.45 p.m. | 20 feet from far end of room. | 69 | 4·6 | 3·0 | – | – | | |
| 7 (177) | Confectioner's bakehouse, Cheltenham, 14 Feb. 1902. | Underground bakehouse (6 to 9 feet below) pavement. | 2,400 (about) | – | 5 | 480 | 4 large gas jets. | 14 Feb. 1902. 7.15 p.m. | Body of room | 68 | 9·8 | 4·3 | – | – | Two sash windows facing area dropped 5 inches. | A fairly good sample of an underground bakehouse; very irregular in shape and only moderately clean. All Swiss occupants. |
| 8 (178) | - ditto - ditto | - ditto - ditto | 2,400 (about) | – | 5 | 480 | – | 15 Feb. 1902. 11.0 p.m. | - ditto - | 65 | 9·4 | 3·4 | – | – | One window dropped 10 inches, one door opened. | |

TABLE I.

## LETTER-PRESS PRINTING, BOOKBINDING, &c.

| Index No. | Business of Firm, Place and Date. | Description of Room. Position, Process, &c. | Cubic contents. | Height. | Number of Occupants and Space. Number present. | Space per Person. | Gas, Oil, or Electric Light. | Date, Time and Position of Test. Date and Time. | Where sampled. | Temperature at same time. | Volumes of $CO_2$ per 10,000. Inside Room. | Outside Air. | Bacteria, &c. per litre of Air. Bacteria. | Moulds. | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (179) | Printing and bronzing, London, E.C., 18 Jan. 1901. | Basement | 24,339 | 10½ | 29 | 839 | E. 3 gas engines. | 18 Jan. 1901, 11.40 a.m. | Between stairs and gas engine. | – | 12·4 | 4·0 (Estimate). | – | – | A window open at pavement level, stairs to room above, machine fan stopped. | Referred to the Committee as "bad." When first visited in the morning the fan was not working, owing to a breakdown, and this made the air much worse than ordinary. |
| 2 (180) | - ditto - ditto | - ditto - ditto | 24,339 | 10½ | 29 | 839 | ditto | 18 Jan. 1901, 5.15 p.m. | - ditto - | – | 7·9 | 4·6 | – | – | 30-inch Blackman fan, in full work; other conditions as before. | The outside conditions tended to fog. On a second visit being paid in afternoon the fan was found in full work, and the air much better, although distinctly foggy outside. |
| 3 (181) | Printing, London, E.C., 11 Jan. 1901. | Top gallery, over lofty machine room. | 64,546 | – | 44 | 1,466 | Gas, 80 jets. | 11 Jan. 1901, 2.55 p.m. | Side of gallery. | – | 19·3 | 5·0 (Fog). | – | – | Practically none. The walls were all windowless for fire protection, and skylights were all closed from fog. | Referred to the Committee as "bad." System of heating: High-pressure steam; small hydraulic pipes (⅜ bore and 1¼ calibre), coiled in furnace and extended throughout faction. Said to be very efficient, rapid, safe, and economical. |
| 4 (182) | - ditto - ditto | Ground floor (machine room). | 72,576 | – | – | – | Gas, 40 jets. | 11 Jan. 1901, 3.10 p.m. | Body of room | – | 15·6 | ditto - | – | – | Same remarks apply. | |
| 5 (183) | Printing and bookbinding, London, W., 15 Jan. 1901. | Ground floor (composing room). | 20,900 | 11 | 35 | 597 | E. L. | 15 Jan. 1901, 3 p.m. | - ditto - | – | 13·3 | 3·5 (Estimate). | – | – | Windows and lanterns all closed. Hoist to floor above. | This was an L-shaped room, occupied by women compositors, and its cleanliness and general appearance were much above the average. Most of the electric lamps were aglow. |
| 6 (184) | - ditto - ditto | Basement (machine room). | 20,000 | 10 | 20 | 1,000 | E. L. and gas engine. | 15 Jan. 1901, 3.35 p.m. | - ditto - | – | 11·9 | ditto - | – | – | Windows closed. Stairs and hoist to floors above. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 (185) | - ditto - ditto | Basement (adjoining last). (Folding room.) | – | – | 6 | – | Gas, 2 jets. | 15 Jan. 1901, 3.40 p.m. | - ditto - | – | 10·1 | - ditto | – | – | Two windows open to area; each dropped 2 inches. | Referred to Committee as "bad," but test did not prove air to be especially so. |
| 8 (186) | - ditto - ditto | Top floor (2nd) (Men's composing room). | 15,000 | 12 | 21 | 714 | Gas, 1 jet. | 15 Jan. 1901, 3.50 p.m. | - ditto - | – | 23·4 | - ditto | – | – | Windows all closed. | Considering that only one gas jet was burning the air here was very impure. A good deal of this was doubtless due to the impure air ascending from occupied rooms below through hoist and stairs. The weather being cold the windows were all closed. As they were made to fold back on bottom hinges they caused draughts when open. |
| 9 (187) | - ditto - ditto | - ditto - ditto | 15,000 | 12 | 21 | 714 | - ditto | 15 Jan. 1901, 4.0 p.m. | - ditto - another position. | – | 25·7 | - ditto | – | | - ditto - ditto | |
| 10 (188) | - ditto - ditto | - ditto - ditto | 15,000 | 12 | 21 | 714 | - ditto | 15 Jan. 1901, 4.5 p.m. | Over hoist well (air from below). | – | 16·5 | - ditto | – | – | - ditto - ditto | |
| 11 (189) | Bookbinding, London, W. C., 16 Jan. 1901. | Ground floor, Blocking shop (small end portion). | 9,600 | 12 | 15 | 640 | Gas, 14 jets & 10 gas presses. | 16 Jan. 1901, 2.15 p.m. (just after dinner). | Body of room | 70½ | 16·5 | - ditto | – | – | Six small windows open in roof lantern. | Room not very clean. Full of gas-heated machinery. The high amount of $CO_2$. (16·5) at 2.15 with temperature 70½° was reduced to 8·2 at 4.30, when temperature became 78°. |
| 12 (190) | - ditto - ditto | - ditto - ditto | 9,600 | 12 | 15 | 640 | - ditto | 16 Jan. 1901, 4.30 p.m. | - ditto - | 78 | 8·2 | - ditto | – | – | - ditto - ditto | |
| 13 (191) | - ditto - ditto | Ground floor (men's case-making room). | – | 11 | 29 | – | Gas, 13 jets. | 16 Jan. 1901, 2.30 p.m. | - ditto - | – | 12·4 | - ditto | – | – | Lantern windows all closed. Two open stairs to floors above. | An average room of its kind—moderately clean—steam-heated. |
| 14 (192) | - ditto - ditto | First floor (women's gold room). | – | – | 34 | – | Gas, 5 jets. | 16 Jan. 1901, 2.35 p.m. | About 7 feet from stairs. | 69½ | 15·6 | - ditto | – | – | One side window opened 8 inches at bottom. One stair to floor above and 2 to floor below. | A fairly clean room. The higher amount of $CO_2$ shows a tendency of impurities to increase on upper floors. |
| 15 (193) | - ditto - ditto | Second floor, top (machine room). | 9,000 | 10 | 4 | 2,250 | Gas, 4 jets. | 16 Jan. 1901, 2.45 p.m. | Body of room | – | 18·8 | - ditto | – | – | Four windows in roof lantern, all open. | This room was immediately over the last one tested, and affords an instance of the collection of impurities in upper floors. Although by far the most thinly occupied, the $CO_2$ was much higher in this room than in either of those below, the respective readings on the ground, 1st and 2nd floors being 12·4, 15·6, and 18·8. The high reading of $CO_2$ (13·8) in the upward current on the stair shows that the impurities were passing upwards. |
| 16 (194) | - ditto - ditto | - ditto - ditto | 9,000 | 10 | 4 | 2,250 | - ditto | - ditto - | Over stairs from gold room below. | – | 13·8 | - ditto | – | – | - ditto - ditto. | |

TABLE I—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 17 (195) | Bookbinding, London, W.C., 16 Jan. 1901. | First floor (forwarding room, women). | – | – | 50 | – | Gas, 20 jets. | 16 Jan. 1901, 3.10 p.m. | Ten feet from large opening. | 75 | 7·8 | 3·5 (Estimate). | – | – | This room formed a sort of gallery round a large opening 30 feet by 10 feet, which served as an inlet from warehouse below. | A fairly clean room. As the warehouse below was thinly occupied the air supplied from that source was cool and fresh. |
| 18 (196) | - ditto - ditto | Second floor (women's stitching room). | – | – | 33 | – | Gas, 13 jets. | 16 Jan. 1901, 3.20 p.m. | Body of room | 68½ | 9·2 | - ditto | – | – | Several side windows open. Hoist and stairs above and below. | This and the following test again shows the accumulation of impurities on upper floors, the readings being: 1st floor 7·8; 2nd floor, 9·2; 4th floor 11·0. As the latter room had no occupants and no lights burning the $CO_2$ must all have been imported from below, through hoist and stairs, there being a large volume of air ascending through both. |
| 19 (197) | - ditto - ditto | Fourth floor, top (empty stores room). | – | – | 0 | – | – | 16 Jan. 1901, 3.40 p.m. | - ditto - | 67½ | 11·0 | - ditto | – | – | Two windows slightly open. | |
| 20 (198) | Newspaper printing and magazines, &c., London, E.C., 25 Jan. 1901. | Composing room. | 49,466 | 10¼ | 60 | 824 | Gas, 1 jet. | 25 Jan. 1901, 11.45 a.m. | - ditto - | – | 11·0 | - ditto | – | – | Side windows and grids near floor all closed. | Floor dusty. |
| 21 (199) | - ditto - ditto | Another composing room. | 16,237 | 13 | 34 | 477 | Gas, 3 jets. | 25 Jan. 1901, 12 noon. | - ditto - | – | 19·3 | - ditto | – | – | - ditto - ditto. | |
| 22 (200) | - ditto - ditto | Another composing room (first half). | 30,706 | 13 | 40 | 767 | Gas, 10 jets. | 25 Jan. 1901, 12.10 p.m. | - ditto - | – | 18·8 | - ditto | – | – | Coke stove; swing door. | Concrete ceilings and floor, the latter covered with impervious wood. Glazed brick walls. |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 23 (201) | - ditto - ditto | Another composing room (second half). | 32,019 | 13 | 30 | 1,067 | – | 25 Jan. 1901, 12.30 p.m. | - ditto - | – | 16·5 | ditto | – | – | As above - - | As above. |
| 24 (202) | Printing and bookbinding, London, E.C., 25 Jan. 1901. | Ground floor (machine printing). | 35,532 | 11¾ | 21 | 1,692 | Gas, 14 jets. | 25 Jan. 1901, 2.5 p.m. (dinner 1 to 2). | - ditto - | – | 4·6 | ditto | – | – | Three windows open. | Test made too soon after dinner. |
| 25 (203) | - ditto - ditto | First floor (composing room) No. 1. | 26,208 | 10⅔ | 50 | 524 | Gas, 31 jets. | 25 Jan. 1901, 2.15 p.m. | - ditto - | – | 11·5 | ditto | – | – | One open window. Hoist above and below. | The outside conditions being dull a considerable amount of gas was being burnt in this room. |
| 26 (204) | - ditto - ditto | First floor (composing room) No. 2. | 32,256 | 10⅔ | 46 | 701 | Gas, 14 jets. | 25 Jan. 1901, 3.0 p.m. | - ditto - | – | 10·1 | ditto | – | – | Five windows open. Cross ventilation. | As above. |
| 27 (205) | - ditto - ditto | Top floor (composing room) No. 3. | 50,400 | 16⅔ | 58 | 869 | Gas, 1 jet. | 25 Jan. 1901, 3.15 p.m. | - ditto - | – | 7·3 | ditto | – | – | Five windows open, and 3 other openings, besides hoist well. | Occupants had apparently been warned to open windows. |
| 28 (206) | - ditto - ditto | First floor (bookbinding). | 32,256 | 10⅔ | 40 | 806 | - ditto | 25 Jan. 1901, 2.25 p.m. | - ditto - | – | 15·6 | ditto | – | – | | |
| 29 (207) | - ditto - ditto | Top floor (composing room) No. 1. | 18,360 | – | 24 | 765 | Gas, 13 jets. | 25 Jan. 1901, 3.30 p.m. | - ditto - | – | 9·4 | ditto | – | – | Tobin tubes stopped up. Windows all closed. | |
| 30 (208) | - ditto - ditto | Top floor (composing room) No. 2. | 8,609 | – | 13 | 662 | Gas, 3 jets. | 25 Jan. 1901, 3.40 p.m. | - ditto - | – | 8·2 | ditto | – | – | One window open. | |
| 31 (209) | - ditto - ditto | Bookbinding (sewing room). | 5,661 | – | 14 | 404 | — | 25 Jan. 1901, 3.50 p.m. | - ditto - | – | 8·6 | ditto | – | – | One window open. Ceiling ventilator. | |
| 32 (210) | - ditto - ditto | Fly press (embossing room). | 6,253 | – | 19 | 329 | Gas, 15 jets. | 25 Jan. 1901, 4 p.m. | - ditto - | 71 | 6·4 | ditto | – | – | Five windows open. Coke fire at one end. | With coke fire at one end and wall rendered very hot by main chimney stack at opposite end, the atmosphere was rendered oppressively dry. |
| 33 (211) | Newspaper printing, London, E.C., 14 Feb. 1901. | Top floor (third) composing room (L-shaped). | 20,284 | 11 | 60 | 338 | – | 14 Feb. 1901, 4.10 p.m. | About 7 feet from hoist. | – | 12·0 | ditto | 0 | 6 | All side and lantern windows closed. Hoist from below. | Outside conditions clear and wintry, hence windows all shut. Floors and cases fairly clean—swept every day. Room steam-heated. |

APPENDIX I.—*continued.*

TABLE I—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 34 (212) | Newspaper printing, London, E.C., 14 Feb. 1901. | Second floor, case room (L-shaped). | 24,098 | 10¼ | 60 | 401 | Gas, 17 jets. | 14 Feb. 1901, 4.30 p.m. | Body of room | – | 16·5 | 3·5 (Estimate). | 9 | 0 | Side windows all closed. Hoist above and below. | Ceiling lower and room not so clean as above. Steam heated. Higher reading of $CO_2$ due to gaslight. |
| 35 (213) | Magazine printing, bookbinding, &c., London, E.C., 21 Feb. 1901. | Small office on ground floor. | 700 | 10 | 1 | 700 | Gas stove. | 21 Feb. 1901, 2.10 p.m. | - ditto - | – | 11·0 | ditto | – | – | Door and window closed. Gas stove alight. | Sample taken because of incomplete combustion from gas stove. This office separated by passage from manufacturing premises. |
| 36 (214) | - ditto - ditto | Fourth floor (top), large composing room. | 159,390 | 17½ | 150 | 1,062 | Gas, 13 jets. | 21 Feb. 1901, 2 25 p.m. | Under end of middle lantern. | – | 12·0 | ditto | 5 | 1 | Side windows closed. Three large Ridge lanterns with windows, the middle range being slightly open on one side. This range is immediately over the main "well" of building. | Very cold day, snowing outside. No special heating except by gas jets, few of which were alight. Stairs and hoist shut off. Fairly clean room, which really forms a quadrangular gallery in open communication with the "well" or central air space, which extends from basement to roof. |
| 37 (215) | - ditto - ditto | - ditto - ditto | 159,390 | 17½ | 150 | 1,062 | - ditto | 21 Feb. 1901, 2.40 p.m. | Under middle of right side lantern. | – | 10·6 | ditto | – | – | | |
| 38 (216) | - ditto - ditto | - ditto - ditto | 159,390 | 17½ | 150 | 1,062 | - ditto | 21 Feb. 1901, 3.45 p.m. | Same position as at 2.25 p.m. | – | 12·4 | ditto | – | – | | |
| 39 (217) | - ditto - ditto | Third gallery, press room (platen machines). | 45,259 | 11 | 40 | 1,131 | Gas, 19 jets. | 21 Feb. 1901, 3.0 p.m. | Just outside electrotype room and near "well." | 67 | 15·2 | ditto | 6 | 6 | Large well or central air space above and below. Windows closed. | This room forms an irregular shaped portion of third gallery. No heating except by gas. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 (218) | - ditto - ditto | Third gallery, electrotype finishing room. | 12,617 | 11 | 20 | 635 | Gas, 10 jets. | 21 Feb. 1901, 3.5 p.m. | Body of room | 74 | 13·8 | - ditto | – | – | One open window, one broken pane; three small openings in partition. Door at one end. | This room adjoined the last, thin partition between them, extending from floor to ceiling. Room of long narrow oblong shape. An unpleasant smell of oil, &c. was probably accentuated by the heat (74°). |
| 41 (219) | - ditto - ditto | Fourth floor (top), in old building, bookbinding, and folding (women). | 15,264 | 12 | 26 | 600 | – | 21 Feb. 1901 3.20 p.m. | - ditto - | 66 | 20·2 | - ditto | 7 | 0 | All windows and skylights closed. Doors each end, for passage to other rooms. Stairs from below. Two chimneys, no fire. | This room was at the top of old portion of same premises. Floor somewhat dusty, but otherwise fairly clean. |
| 42 (220) | - ditto - ditto | Fourth floor (top), in old building, another folding room. | 23,562 | 11 | 35 | 673 | – | 21 Feb. 1901, 3.35 p.m. | - ditto - | 62 | 25·4 | - ditto | 10 | 2 | Side windows and skylights all closed. One door to next room only. | This room was a step or two higher than the last one, and being the farthest room of three from main building there was no through passage, and consequent opening of doors. Somewhat dusty, otherwise fairly clean. The atmosphere was highly impure, considering the absence of gas light. |
| 43 (221) | - ditto - ditto | Basement, machine printing. | 200,772 | 18 | 140 | 1,434 | Gas, 20 jets. | 21 Feb. 1901, 4.0 p.m. | - ditto - | 63 | 10·0 | - ditto | 4 | 0 | Enormous head space in "well" above. Side windows all closed. Stairs and hoist to floors above. | This was a huge floor of average cleanliness and appearance, full of machinery, but sparsely occupied by men. The number of gas lights almost equalled the number of persons, considering which the reading of $CO_2$ was low. |
| 44 (222) | - ditto - ditto | - ditto - ditto | 200,772 | 18 | 140 | 1,434 | ditto | 21 Feb. 1901, 4.5 p.m. | Body of room, another position. | 63 | 10·5 | - ditto | – | – | | |
| 45 (223) | Magazine printing and bookbinding, Buckinghamshire, 23 April 1901. | Ground floor, new building (machine printing). | 84,840 | 14 | 35 | 2,424 | – | 23 Apr. 1901, 1.5 p.m. (hands just leaving for dinner). | Body of room | – | 3·5 | 2·8 | – | – | Twenty-five windows with louvred panes open; doors open; and one 24-inch extracting propeller fan working. | A well proportioned and very light, clean, airy room. Glazed brick walls and painted iron work. Weather exceedingly warm; some wind. |
| 46 (224) | - ditto - ditto | Ground floor, old portion (machine printing). | 60,222 | 13 | 40 | 1,505 | – | 23 Apr. 1901, 12.55 noon (just before dinner). | - ditto - | – | 6·0 | - ditto | 5 | 0·5 | Few side windows open. | |

APPENDIX I.—*continued.*

TABLE I—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 47 (225) | Magazine printing and bookbinding, Buckinghamshire, 23 April 1901. | Third floor, top (men's composing room). | 44,825 | 12¼ | 53 | 846 | – | 23 Apr. 1901, 3.45 p.m. | Body of room | 70 | 4·6 | 2·8 (Estimate). | – | – | Twenty side windows all closed and every chink stopped up. One roof ventilator slightly open out of six. | Fairly clean room. Unnecessarily close considering the very favourable outside conditions. |
| 48 (226) | - ditto - ditto | - ditto - ditto | 44,825 | 12¼ | 53 | 846 | – | 23 Apr. 1901, 4.0 p.m. | Body of room (more crowded spot). | 70 | 6·0 | - ditto | 0·5 | 0 | | |
| 49 (227) | - ditto - ditto | Third floor, top (women's composing room). | 31,762 | 12½ | 37 | 858 | – | - ditto - | Body of room | 71½ | 3·5 | - ditto | | – | Side windows all round, ten of which had fanlights wide open. | Good instance of the preference that women have for fresh air as compared with men (see last test). Very clean, light room, under roof, and consequently hot from external conditions. |
| 50 (228) | - ditto - ditto | - ditto - ditto | 31,762 | 12½ | 37 | 858 | – | 23 Apr. 1901, 4.8 p.m. | Body of room (more crowded spot). | 71½ | 3·8 | - ditto | 2 | 0 | | |
| 51 (229) | - ditto - ditto | Second floor (folding room). | 43,653 | 10¼ | 105 | 416 | – | 23 Apr. 1901, 4.30 p.m. | Body of room | – | 4·1 | - ditto | 3 | 0 | Side windows with 18 fanlights wide open. One door open. | Another clean, light, airy room. |
| 52 (230) | - ditto - ditto | First floor (bookbinding). | 52,115 | 11¼ | 62 | 840 | – | 23 Apr. 1901, 4.45 p.m. | - ditto - | – | 3·7 | - ditto | – | – | Side windows with 15 fanlights open. | A fairly clean room, and the most crowded of any in this factory, not only with persons, but with plant and large piles of material, printed paper, and finished books. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 53 (231) | Lithograph and letterpress printing, London, S.E., 10 Oct. 1901. | First floor (machine printing). | 40,950 | 14 | 27 | 1,516 | – | 10 Oct. 1901, 12 noon. | Body of room | | 8·8 | 3·5 (Estimate). | – | – | Three windows (each 3 ft. by 2 ft.) open. Fifteen other windows did not fit close. Air shaft in corner closed. | A typical printing machine room, with six windows (5 ft. by 6 ft. 6 in.) on each of the three sides. Three swing casements apparently opened just as we entered. |
| 54 (232) | - ditto - | ditto | Second floor (litho-printing machine room). | 40,950 | 14 | 30 | 1,365 | Gas, 5 jets. | 10 Oct. 1901, 12.15 noon. | - ditto - | – | 6·4 | ditto | – | – | Eighteen windows all closed, but bad fit. One door open; another glass door with three panes out. | A strong inward draught at open door and at all chinks in windows. |
| 55 (233) | Newspaper printing office, Bristol, 7 Nov. 1901. | Second floor (top), linotype composing. | 28,509 | 17 | 21 | 1,357 | E.L. (all on). | 7 Nov. 1901, 12.15 midnight. | - ditto - | – | 6·6 | 4·2 (fog). | – | – | Windows and door closed; four ventilators in roof, (?) if open. | This test was made on a cold, foggy night. Room was not very crowded, and the general conditions very fair. No gas alight, except for melting pots of linotype. |
| 56 (234) | - ditto - | ditto | Second floor (top), small annexe of same room (hand composing). | 2,618 | 11 | 4 | 654 | E.L. | 7 Nov. 1901, 12.20 midnight. | - ditto - | – | 12·8 | ditto | – | – | - ditto - dltto. | The small hand-composing annexe was not partitioned off from this room, and the higher reading of $CO_2$ was probably due to there being less space per person. |
| 57 (235) | Newspaper printing, Bath, 7 Nov. 1901. | Ground floor (hand composing). | – | – | 20 (5 more had just gone). | – | Gas, 23 jets. | 7 Nov. 1901, 9.10 p.m. | Body of room, between two rows of cases and near fanlights. | – | 12·0 | 4·9 (fog). | – | – | Six large fanlights open at one end. | This room had been occupied since 8.30 a.m. (12½ hours less meals). Old building, ceiled roof. Moderately clean; not particularly hot. Outside air rather damp. A test was made in the unoccupied portion of this room, which shows it to be affected by impurities from gas and occupants in other parts. |
| 58 (226) | - ditto - | ditto | - ditto - | ditto | – | – | 20 (5 more had just gone). | – | – | 7 Nov. 1901, 9.15 p.m. | Body of room, same part, farther from fanlights. | – | 13·8 | ditto | – | – | - ditto - ditto. |
| 59 (237) | - ditto - | ditto | Extension of same room (bookbinding). | – | – | – | – | All dark since 8.30 p.m. | 7 Nov. 1901, 9.20 p.m. | An occupied extension of same room. | – | 12·8 | ditto | – | – | Open to the larger room; also room open to passage. | |
| 60 (238) | Litho-printing and bookbinding, Liverpool, 18 Jan. 1902. | Third floor, L-shaped room, (litho-printing). | 40,144 | 8¼ | 50 | 803 | Gas, 29 jets. | 18 Jan. 1902, 11.35 a.m. | Centre of angle. | – | 6·3 | 2·7 | – | – | Two exhaust fans with trunks, &c. working. Hoist and stairs above and below. | Referred to Committee as "very unsatisfactory," especially as on this floor it is necessary to burn gas even in broad sunlight. The building appeared old and the interior none too clean; the ceiling low. The results are, however, low. |
| 61 (239) | - ditto - | ditto | - ditto - | ditto | 40,144 | 8¼ | 50 | 803 | ditto | 18 Jan. 1902, 11.30 a.m. | One extremity of room. | – | 8·0 | 2.7 | – | – | - ditto - ditto. |
| 62 (240) | - ditto - | ditto | - ditto - | ditto | 40,144 | 8¼ | 50 | 803 | ditto | 18 Jan. 1902, 11.45 a.m. | Near belt-hole and uptake from engine-house. | – | 4·6 | 2·7 | – | – | — |

TABLE I.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 63 (241) | Litho-printing and bookbinding, Liverpool, 18 Jan. 1902. | Fourth floor (top) bookbinding. | 67,313 | 13⅔ | 40 | 1,682 | – | 18 Jan. 1902, 11.50 a.m. | Body of room | – | 5·7 | 2·7 | – | – | No windows open. Roof not very tight. | Room not particularly clean. Unceiled roof. |
| 64 (242) | Letterpress printing, Bristol, 26 Oct. 1901. | Basement (machine room). | 12,250 | 8½ | 15 | 817 | Daylight | 26 Oct. 1901, 11.35 a.m. | - ditto - | – | 3 9 | 3·5 (Estimate). | – | – | One window open stairs to room above. | Referred to Committee as "unsatisfactory and difficult to ventilate." |
| 65 (243) | Newspaper printing, Bristol, 31 Oct. 1901. | Third floor (top), L shaped room, hand composing. | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 31 Oct. 1901, 9.58 p.m. | - ditto - | 70 | 14·3 | ditto | – | – | One window slightly open, one trap door open, 3 ventilators and Tobin tubes stopped up. | These samples were taken on a cool, dry October night: north-east wind blowing. A very clean, orderly room, rather warm and air not very fresh. The gas jets were to occupants as 3 to 2, and the men had been at work since 8.30 p.m. |
| 66 (244) | - ditto - ditto | - ditto - ditto | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 31 Oct. 1901, 10 p.m. | Body of room, more crowded spot. | 70 | 14·9 | ditto | – | – | | |
| 67 (245) | - ditto - ditto | - ditto - ditto | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 31 Oct. 1901, 10.5 p.m. | Same place | 70 | 15·4 | ditto | – | – | | |
| 68 (246) | Newspaper printing, Bristol, 7 Nov. 1901. | - ditto - ditto | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 7 Nov. 1901, 12.30 midnight. | Body of room, same as No. 65. | 72 | 12·4 | 4·2 | – | – | Same as before - | This was another series of samples taken a week later at midnight in the same composing room, when the conditions would be at their worst. The weather outside was rather foggy and cold. Inside the air was stuffy. The room had been occupied since 8.30 p.m. |
| 69 (247) | - ditto - ditto | - ditto - ditto | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 7 Nov. 1901, 12.35 a.m. | Body of room, more crowded spot. | 72 | 16·8 | 4·2 | – | – | Same as before. | |
| 70 (248) | - ditto - ditto | - ditto - ditto | 55,721 | 15⅓ | 64 | 870 | Gas, 103 jets. | 7 Nov. 1901, 12.38 a.m. | Same place | 72 | 19·5 | 4·2 | – | – | Same as before. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6605 F 2 | 71 (249) | Another newspaper printing works, Bristol, 31 Oct. 1901. | Second floor (top), hand composing and linotype room. (*See* remarks). | 38,970 | 22½ | 16 hand, 12 Lino. | 1,391 | Gas 48 jets and E.L. 12 lamps. | 31 Oct. 1901, 10.27 p.m. | Hand - composing portion. | – | { 3·9 / 4·3 } | 3·5 | – | – | Four large outlet air shafts, depending from ridge of roof. 7 Tobin inlets, some closed. Door open from stairs and large volume of air entering. | This was another newpaper composing room sampled at first on a cool, dry October night, north-east wind blowing. The room was shaped like an L, one leg serving for the hand composing department and the other for the Linotype machines, the former being lighted by gas and the latter by electricity. The gas jets were large, and considerably outnumbered the occupants. |
| | 72 (250) | - ditto - ditto | - ditto - ditto | 38,970 | 22½ | ditto | 1,391 | ditto | 31 Oct. 1901, 10.32 p.m. | Linotype portion. | – | 8·8 | 3·5 | – | – | - ditto ditto. | |
| | 73 (251) | Same newspaper printing works, Bristol, 7 Nov. 1901. | - ditto - ditto | 38,970 | 22½ | ditto | 1,391 | ditto | 7 Nov. 1901, 1 a.m. | - ditto - | 78 | 20·3 | 4·2 | – | – | The air shafts were said to be open. The Tobin tubes and large door were closed. | Samples of air were taken a week later in the dead of night, with a cold fog prevailing outside; no wind. On this occasion the doors and Tobin tubes had been closed to exclude the fog, and the air was very much less pure than before. The door being closed made a considerable difference, and after the Tobin tubes had been open 5 or 6 minutes the $CO_2$ dropped from 20·3 to 19·0. |
| | 74 (252) | - ditto ditto - | - ditto - ditto | 38,970 | 22½ | ditto | 1,391 | ditto | 7 Nov. 1901, 1.10 ..m. | - ditto - | 78 | 19·0 | 4·2 | – | – | The Tobin tubes were open 5 or 6 minutes to see the effect, but the large door remained closed. | |
| | 75 (253) | - ditto ditto - | - ditto - ditto | 38,970 | 22½ | ditt | 1,391 | ditto | 7 Nov. 1901, 1.5 a.m. | Hand - composing portion. | 78 | 15·4 | 4·2 | – | – | Same as above - | The hand-composing portion of room shows a lower reading of $CO_2$ although considerably more gas jets and a larger number of hands were employed in it. This was because the extra heat from gas assisted the ventilation by means of the Tobin tubes, of which the larger number were in this part of the room. |

APPENDIX I.—*continued.*

TABLE J.

STATIONERY, CARDBOARD BOXES, &c.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (254) | Paper embossing, London, E.C., 11 Jan. 1901. | Basement, press room. | 7,369 | 8½ | 10 | 737 | Gas, 7 jets. | 11 Jan. 1901, 12.35 p.m. | Body of room | – | 13·3 | 6·0 (thick fog). | – | – | Ventilated by trunk or air shaft through rooms above. Windows closed. | Referred to the Committee as "bad." Room very cool. Air somewhat dusty. Becoming very foggy outside. ($CO_2$ = 6·0.) |
| 2 (255) | Cardboard box-making, London, E.C., 11 January 1901. | Second floor, women's box making room. | 20,803 | 11½ | 20 | 1,040 | Gas, 14 jets. | 11 Jan. 1901, 2.20 p.m. | - ditto - | – | 12·8 | 6·4 (thick fog). | – | – | Windows in side wall, some slightly open. | A large, clean workroom, much above average space per person. Apparently well ventilated by ordinary windows. Very little dust. |
| 3 (256) | - ditto - ditto | Third floor (top), women's box making room. | 10,584 | 12 | 14 | 756 | Gas, 8 jets. | 11 Jan. 1901, 4.10 p.m. (tea-time). | - ditto - | – | 11·9 | 5·0 (fog subsiding). | – | – | Windows in roof, few open. | Old building, rooms under roof. Heated by steam, and seemed very hot. Unpleasant smell of glue, &c., otherwise moderately clean. |
| 4 (257) | Envelope making, London, E.C., 14 Jan. 1901. | Ground floor, large envelope machine room. | 30,100 | 14 | 30 | 1,000 | Gas, 24 jets. | 14 Jan. 1901, 12 noon. | - ditto - | – | 4·1 | 3·5 (Estimate). | – | – | Air blown in through six machines for drying envelopes. A few windows and fanlights slightly open. | Referred to Committee as "unsatisfactory"; but test showed the air to be very pure. This room furnishes a good instance of ventilation being achieved by fans not specially intended for the purpose, but used in connection with the machines for drying purposes. Six such machines drew their supply from outside, and discharged inside the room. Others which derived and discharged their supply in the same room effected no such ventilation. |
| 5 (258) | - ditto - ditto | - ditto - ditto | 30,100 | 14 | 30 | 1,000 | Gas, 24 jets. | 14 Jan. 1901, 12.5 noon. | - ditto - | – | 4·6 | ditto | – | – | - ditto - ditto - | |
| 6 (259) | - ditto - ditto | - ditto - ditto | 30,100 | 14 | 30 | 1,000 | Gas, 24 jets. | 14 Jan. 1901, 12.15 p.m. | Body of room, another position. | – | 5·0 | ditto | – | – | - ditto - ditto - | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 (260) | - ditto - ditto | Ground floor, small machine room adjoining above. | 10,836 | 14 | 14 | 774 | Gas, 14 jets. | 14 Jan. 1901, 12.30 p.m. | Body of room | – | 15·6 | ditto | – | – | Practically no ventilation; skylights closed, and door the only ingress for air. Several machines took air at top of room, and blew it through machines. | A much less satisfactory room. No ordinary ventilation, and machines did not ventilate, but merely circulated the impure air of room. |
| 8 (261) | Stationery, London, E.C., 14 Jan. 1901. | Basement, paper folding. | 15,200 | 10 | 27 | 563 | Gas, 15 jets. | 14 Jan. 1901, 2.30 p.m. | Near fan and stairs, 10 feet away. | – | 9·9 | 3·5 (Estimate.) | – | – | 24-inch extracting fan working. Windows all closed. Stairs to floor above. | Referred to Committee as "unsatisfactory." The fan making 700 revolutions per minute placed too near stairs, short circuited when stairs door open. Windows on opposite side closed on account of draught; hopper windows suggested. The cleanliness and general conditions were rather above average. |
| 9 (262) | - ditto - ditto | - ditto ditto | 15,200 | 10 | 27 | 563 | Gas, 15 jets. | 14 Jan. 1901, 2.35 p.m. | Near fan and stairs, 20 feet away. | – | 12·8 | ditto | – | – | — | |
| 10 (263) | Tobacco, stationery, Bristol, 15 Oct. 1901. | Second floor (top), cigarette mouthpiece machine-room (women). | 70,702 | – | 220 | 321 | 153 small gas jets on machines. | 15 Oct. 1901, 12.45 p.m. (just before dinner). | Body of room | – | 8·3 | ditto | – | – | Fourteen windows on two sides of room, two panes open in each. Hoist and stairs from below. Archimedean ventilator in roof. | Outside conditions favourable, fine October day, fairly warm. A well-appointed, clean-looking room, and apparently well-ventilated by ordinary means. The rooms below sparsely occupied. |
| 11 (264) | - ditto - ditto | - ditto - ditto | 70,702 | – | 220 | 321 | ditto | 15 Oct. 1901, 12.50 p.m. | End where least ventilation. | – | 7·8 | ditto | – | – | — | |
| 12 (265) | - ditto - ditto | - ditto - ditto | 70,702 | – | 223 | 317 | 153 small gas jets on machines, E. L. all on. | 14 Nov. 1901, 6.55 p.m. | Body of room | – | 8·8 | 3·3 (actual). | – | – | Same as above - | These samples were taken with all electric light on to compare with those taken previous month in the daylight. They were taken just before closing time (7.0 p.m.), when the air would probably be at its worst, but there seemed little difference in its purity as compared with daylight, the outside conditions being much less favourable. |
| 13 (266) | - ditto - ditto | - ditto - ditto | 70,702 | – | 223 | 317 | ditto | 14 Nov. 1901, 6.58 p.m. | End where least ventilation. | – | 8·8 | ditto | – | – | - - ditto. | |
| 14 (267) | Cardboard box-making, Bristol, 31 Oct. 1901. | Second floor, women's department. | 54,450 | – | 150 | 363 | E. L. | 31 Oct. 1901, 9.32 p.m. | Body of room | – | 6·3 | 3·5 | – | – | Some small windows open. | Hands had been working overtime and were just leaving when this sample was taken. |

TABLE K.

ENGINEERING AND METAL TRADES.

| Index No. | Business of Firm, Place and date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (268) | Art metal works. London, S.W., 15 Jan. 1901. | Fourth floor (top) brass finishing, (L shaped room). | 7,896 | 8½ | 24 | 329 | – | 15 Jan. 1901, 12 noon. | Body of room | – | 15·5 | 3·5 (Estimate). | – | – | Several windows in side walls closed. One skylight open. Two air grids in floor from room below. | An old building, rather dusty room, air unpleasant. Another instance of a top room suffering from impurities largely imported from below, as will be seen from the result of a special test made over the grid in floor, through which air containing 12·8 vols. of $CO_2$ was rising from shop underneath. |
| 2 (269) | - ditto - ditto | - ditto - ditto | 7,896 | 8½ | 24 | 329 | – | 15 Jan. 1901, 12.5 noon. | Body of room, another part. | – | 16·4 | ditto | – | – | | |
| 3 (270) | - ditto - ditto | - ditto - ditto | 7,896 | 8½ | 24 | 329 | – | 15 Jan. 1901, 12.10 noon. | Over grid admitting air from below. | – | 12·8 | ditto | – | – | | |
| 4 (271) | - ditto - ditto | Fourth floor (top) tinning shop. | 16,920 | 12 | 20 | 846 | – | 15 Jan. 1901, 1.5 p.m. (dinner hour) 1 to 2. | Body of room | – | 6·4 | ditto | – | – | Windows open on each side. | Top room in another part of old building. Roof and windows not very tight. Shop not very clean; smell of acid fumes. Occupants just leaving for dinner. |
| 5 (272) | - ditto - ditto | First floor, brazing shop. | 18,000 | 10 | – | – | – | 15 Jan. 1901, 1.20 p.m. | - ditto - | – | 10·0 | ditto | – | – | One window open - | A rather dirty shop; occupants had gone out some twenty minutes. |
| 6 (273) | Ordnance armaments, &c., London, S.E. 17 Jan. 1901. | Ground floor, engineering machine shop. | 152,220 | 21 | 120 | 1,800 | – | 17 Jan. 1901, 12.40 p.m. | - ditto - | – | 12·4 | ditto | – | – | Gable windows, and large door, open. 12 ventilators. | Air unsatisfactory, considering the space per person, and the number of so-called ventilators. |
| 7 (274) | - ditto - ditto | Ground floor, small machine shop adjoining. | 64,000 | 21 | | | | 17 Jan. 1901, 12.45 p.m. | Body of room, another position. | – | 14·6 | ditto | – | – | Gable windows, and Ridge ventilators. | - ditto ditto. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 (275) | - ditto - ditto | First floor, engineering, gauge shop. | 60,345 | 12 | 50 | 1,212 | – | 17 Jan. 1901, 2.45 p.m. (dinner 1 to 2) | Least crowded portion of room. | 57½ | 13·3 | ditto | – | – | Gable windows, and Ridge ventilators all closed. Stairs shut off. | A badly ventilated room (specially complained of) considering large space and no contamination from below. The impurity specially noticeable with all gas on. |
| 9 (276) | - ditto - ditto | - ditto - ditto | 60,345 | 12 | 50 | 1,212 | – | 17 Jan. 1901, 2.48 p.m. | More crowded portion. | – | 13·8 | ditto | – | – | | |
| 10 (277) | - ditto - ditto | - ditto - ditto | 60,345 | 12 | 50 | 1,212 | Gas, 55 jets. | 17 Jan. 1901, 4.45 p.m. (all gas on). | . ditto - | – | 24·4 | ditto | – | – | | |
| 11 (278) | - ditto - ditto | Ground room, engineering, main factory. | 957,185 | 16 | 1,100 | 870 | – | 17 Jan. 1901, 3.25 p.m. | Body of room | – | 6·4 | 3·2 | – | – | Thirty-six gable windows and 54 roof-lights, nearly all wide open. | The windows in this huge shop were unusually wide open, and the air particularly fresh and good. It is not improbable that the unavoidable pre-announcement of our visit had something to do with this. |
| 12 (279) | - ditto - ditto | - ditto - ditto | 957 185 | 16 | 1,100 | 870 | – | 17 Jan. 1901, 3.30 p.m. | - ditto - (Another position). | – | 6·0 | 3·2 | – | – | | |
| 13 (280) | - ditto - ditto | First floor, electric fittings shop. | 31,080 | 10 | 200 | 155 | Gas, 19 jets. | 17 Jan. 1901, 3.50 p.m. | Body of room | – | 8·2 | 3·2 | – | – | One 42-inch Blackman fan at end of shop; 15 sash windows, five skylights (each 3 feet by 2 feet), 20 air bricks, and several Tobin tubes. | Long, narrow, unsuitable building, and greatly overcrowded; a room in which the air would undoubtedly have been very bad but for the unusually large amount of mechanical and natural ventilation. The ground space was only 15·5 square feet per person, and the cubic space 155·4. |
| 14 (281) | - ditto - ditto | - ditto - ditto | 31,080 | 10 | 200 | 155 | ditto | 17 Jan. 1901, 3.55 p.m. | - ditto - | – | 8·2 | 3·2 | – | – | | |
| 15 (282) | ditto - ditto | Ground floor, cartridge making (rolling mill). | 219,220 | 16 | 130 | 1,686 | E.L. | 17 Jan. 1901, 4.20 p.m. | - ditto - | – | 3·2 | 3·2 | – | – | Large side windows all round and big doorway wide open. | As might be expected from the space and ventilation, the air in this room was as good as that outside. |
| 16 (283) | - ditto - ditto | First floor, cartridge making. | 265,915 | – | 226 | 1,176 | E.L. | 17 Jan. 1901, 4.30 p.m. | - ditto - | – | 5·0 | 3·2 | – | – | Windows on three sides of room; Ridge ventilators all along each of two bays in roof, skylights at intervals (mostly open). | —— |
| 17 (284) | Railway carriage and locomotive works, Wiltshire, 14 March 1901. | Ground floor, coppersmiths' shops. | 169,050 | 23 | 150 | 1,727 | – | 14 Mar. 1901, 12 noon. | - ditto - | – | 8·2 | – | – | – | Long Ridge louvred lantern whole length of roof (one bay); seven cowls and uptakes over coke fires at near end; five raised louvres at far end; five side windows (all open). | A well-constructed shop of its kind, and very clean. It was stated that in certain weathers fumes were found to collect at end of shop farthest from coke fires. |

TABLE K.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time of Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 18 (285) | Railway carriage and locomotive works. | Ground floor, brass moulding. | 188,591 | 27 | 100 | 1,885 | – | 14 Mar. 1901, 12.30 p.m. | Body of room | – | 4·6 | 3·5 (Estimate). | – | – | Ridge ventilator (three bays), six open windows in gables of each bay. Several large oval air grids behind the cover pots, in front of which there was an inlet passage below the footplates. | A very clean-looking foundry with effective ventilation. Room free from fumes at the time of visit. |
| 19 (286) | - ditto - ditto | Ground floor, brass finishing. | 188,591 | 27 | 175 | 1,077 | Gas, 10 jets. | 14 Mar. 1901, 12.45 p.m. | - ditto - | – | 11·0 | - ditto | – | – | All windows and Ridge ventilators closed. | This was a lofty, clean-looking building, but the air oppressive. Although ample means of ventilation was provided, everything had been kept closed up at the request of the workmen, whose employment entailed but little muscular exercise. They objected to fresh air on the grounds that it reduced the temperature. There were about 50 gas jets turned quite low, equalling in effect about 10 ordinary flames. |
| 20 (287) | - ditto - ditto | Ground floor, brass - dipping and lacquering. | 29,859 | 24½ | 24 | 1,244 | – | 14 Mar. 1901, 1 p.m. | - ditto - | – | 13·8 | - ditto | – | – | One powerful Root's blower extracting fumes from dipping troughs. Walls all windowless, and Ridge ventilator closed. | In this large shop but 10 persons are ordinarily employed, but 24 happened to be present at time of test. As the shop was surrounded on all sides by other buildings, it depended entirely on its skylights for light and ventilation, except for the mechanical arrangement for extracting fumes. If the emery wheels had fan connections the general ventilation would be much improved. |

TABLE L.

FILE CUTTING. SAMPLES TAKEN IN DAYLIGHT BY COMMITTEE.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (288) | File-cutters' workshop, Sheffield, 14 May 1902. | Ground floor, shed | 1,198 | 8¾ | 4 | 299 | – | 14 May 1902, 4.10 p.m. | Middle of shop | – | 5·2 | 3·1 | – | – | Two windows open, and some other panes broken. Fire flue. | This and the following tests were made by the Committee on a clear, cold, bright, dry day; slight northerly breeze. In this shop four men only were at work, but "stocks" were provided for six. Brick walls, rough stone floor, dusty, fire lit, slate roof. |
| 2 (289) | - ditto - ditto | - ditto - ditto | 720 | 7½ | 3 | 240 | – | 14 May 1902, 4.40 p.m. | - ditto - | – | 8·7 | 3·1 | – | – | Fire flue. Window just opened, and others broken. | Rather overcrowded, fairly clean walls, rough brick floor. |
| 3 (290) | - ditto - ditto | - ditto - ditto | 1,350 | 9 | 3 | 450 | – | 14 May 1902, 3.40 p.m. | - ditto - | – | 5·0 | 3·1 | – | – | Fire lit; windows all along front (some slightly open). | Three men only were present, but several "stocks" were unoccupied. Ordinary lean-to shed with brick walls and slate roof. |
| 4 (291) | - ditto - ditto | - ditto - ditto | 1,232 | 8 | 3 | 410 | – | 14 May 1902, 4.25 p.m. | - ditto - | – | 6·6 | – | – | – | Fire lit; no other ventilation. | Room rather rough and dusty; air somewhat close; wooden floor. |
| 5 (292) | - ditto - ditto | - ditto - ditto | 768 | 8 | 3 | 256 | – | 14 May 1902, 4.50 p.m. | - ditto - | – | 7·3 | – | – | – | One window wide open; several broken, fire lit. | Small lean-to shed, rough brick floor, slate roof. |
| 6 (293) | - ditto - ditto | ditto - ditto | 512 | 8 | 2 | 256 | – | 14 May 1902, 5 p.m. | - ditto - | – | 6·4 | – | – | – | Window, open - | Average conditions; rather loose slate roof. |

## APPENDIX I.—*continued.*

TABLE L.—*contin*

| Index No. | Business of Firm, Place, and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c., per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where Sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 7 (294) | File cutters' workshop, Sheffield, 16 May 1902. | Ground floor, shed | 2,457 | 10½ | 7 | 351 | – | 16 May 1902, 11.30 am. | Middle of shop | – | 9·6 | 3·5 (Estimate.) | – | – | One window open. Two air bricks, one fire lit, one forge not lit. | The following tests were made under much less favourable outside conditions, the weather being dull, damp, cold and raw. A very clean, light shop of modern construction as compared with the foregoing. Brick floor, with raised portion (for "stocks") of loose earth and ashes. One vacant "stock." |
| 8 (295) | - ditto - ditto | Ground floor (practically a basement with house over). | 1,028 | 8½ | 1 | 1,028 | – | 16 May 1902, 12.10 p.m. | - ditto - | – | 4·6 | ditto | – | – | Fire lit; one pane broken; no other vent. | Part of a dwelling-house, and rather dirty. Only one occupant and one vacancy. Occupier says he has worked at file-cutting 43 years without injury. |
| 9 (296) | - ditto - ditto | - ditto - ditto | 880 | 8 | 2 | 440 | – | 16 May 1902, 12.20 p.m. | - ditto - | – | 8·2 | ditto | – | – | Doors open and fire lit. | Two occupants, and another had just gone out. Wall and floor of stone; fairly clean. Lancashire system of "stocks." |
| 10 297) | - ditto - ditto | Ground floor, shed | 1,584 | 9 | 5 | 328 | – | 16 May 1902, 12.50 p.m. | - ditto - | – | 6·9 | ditto | – | – | One window open, 24 in. by 15 in. Three air bricks. | Conditions above the average. Fairly modern, and comparatively well-constructed shop. Clean brick floor; walls newly lime-washed. Five occupants and one vacancy. |

## Samples taken in Daylight by Dr. Robertson.

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 11 (298) | File-cutting, Sheffield, 20 Nov. 1900. | Ground floor, file-cutting | 896 | – | 4 | 224 | – | 20 Nov. 1900, 3.35 p.m. | — | 40·5 (outside) | 5·2 | Not recorded | – | – | Fire lit; no other ventilation (casement windows closed). | This and the following observations form a series carried out by Dr. Robertson, Medical Officer of Health for Sheffield, in typical file-cutting shops in different parts of that town during the winter months, when the windows were all closed. It will be observed from the figures given in Column 7 that most of these workshops were overcrowded, and few provided the requisite 250 cubic feet per person. The analyses were made by a special modification of Pettenkofer's method of bubbling the air through baryta water. Samples 14 to 25 were taken by daylight, and Samples 26 to 39 by artificial light (lamps and candles). |
| 12 (299) | - ditto - ditto | - ditto - ditto | 1,080 | – | 6 | 180 | – | 20 Nov. 1900, 3.50 p.m. | — | ditto | 9·8 | ditto | – | – | - ditto - ditto. | |
| 13 (300) | - ditto - ditto | - ditto - ditto | 812 | – | 4 | 203 | – | 20 Nov. 1900, 4.30 p.m. | — | ditto | 14·3 | ditto | – | – | Holes in top of door | |
| 14 (301) | File-cutting, Sheffield, 21 Nov. 1900. | - ditto - ditto | – | – | – | – | – | 21 Nov. 1900, 2.50 p.m. | — | 44·2 (outside) | 11·0 | ditto | – | – | Fire lit; no other ventilation. | |
| 15 (302) | - ditto - ditto | - ditto - ditto | 600 | – | 3 | 200 | – | 21 Nov 1900, 3.20 p.m. | — | ditto | 13·8 | ditto | – | – | - ditto - ditto. | |
| 16 (303) | - ditto - ditto | - ditto - ditto | 585 | – | 3 | 195 | – | 21 Nov. 1900, 3.30 p.m | — | ditto | 9·6 | ditto | – | – | - ditto - ditto. | |
| 17 (304) | File-cutting, Sheffield, 26 Nov. 1900. | - ditto - ditto | 868 | – | 4 | 217 | – | 26 Nov. 1900, 3.55 p.m. | — | 46·9 (outside) | 20·6 | ditto | – | – | - ditto - ditto. | |
| 18 (305) | - ditto - ditto | - ditto - ditto | 780 | – | 5 | 156 | – | 26 Nov. 1900, 3.10 p.m. | — | ditto | 19·0 | ditto | – | – | - ditto - ditto. | |
| 19 (306) | - ditto - ditto | - ditto - ditto | 896 | – | 4 | 224 | – | 26 Nov. 1900, 3.20 p.m. | — | ditto | 14·0 | ditto | – | – | One 9-inch opening. Fire lit. | |
| 20 (307) | File-cutting, Sheffield, 5 Feb. 1901 | - ditto - ditto | 1,050 | – | 3 | 350 | – | 5 Feb. 1901, 3.0 p.m. | — | 35·1 (outside) | 11·2 | ditto | – | – | Fire lit; no other ventilation. | |
| 21 (308) | - ditto - ditto | - ditto - ditto | 916 | – | 4 | 229 | – | 5 Feb. 1901, 3.10 p.m. | — | ditto | 7·8 | ditto | – | – | - ditto - ditto. | |
| 22 (309) | - ditto - ditto | - ditto - ditto | 588 | – | 3 | 196 | – | 5 Feb. 1901, 4.5 p.m. | — | ditto | 13·9 | ditto | – | – | - ditto - ditto. | |
| 23 (310) | - ditto - ditto | - ditto ditto | 1,425 | – | 3 | 475 | – | 5 Feb. 1901, 4.10 p.m. | — | ditto | 8·0 | ditto | – | – | - ditto - ditto. | |
| 24 (311) | File-cutting, Sheffield, 4 March 1901. | - ditto - ditto | 1,100 | – | 5 | 220 | – | 4 Mar. 1901, 2.35 p.m. | — | 43·3 (outside) | 14·0 | ditto | – | – | - ditto - ditto. | |
| 25 (312) | - ditto - ditto | - ditto - ditto | 584 | – | 4 | 146 | – | 4 Mar. 1901, 2.55 p.m. | — | ditto | 13·2 | ditto | – | – | - ditto - ditto. | |

## APPENDIX I.—*continued.*

### TABLE L.—*continued.*

SAMPLES TAKEN IN ARTIFICIAL LIGHT BY DR. ROBERTSON.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric, Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15). | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic Feet.* | | | | *Degrees.* | | | | | | |
| 26 (313) | File-cutting, Sheffield, 20 Nov. 1900. | Ground floor, file cutting. | 999 | – | 3 | 333 | 2 oil lamps, lit few minutes. | 20 Nov. 1900, 4.55 p.m. | — | 40·5 (outside) | 10·6 | Not recorded. | – | – | Fire lit; no other ventilation. | |
| 27 (314) | File-cutting, Sheffield, 26 Nov. 1900. | - ditto - ditto | 1,272 | – | 6 | 212 | 3 oil lamps. | 26 Nov. 1900, 4.30 p.m. | — | 46·9 (outside) | 18·9 | ditto | – | – | Fire lit; two 9-inch openings. | Clean shop. |
| 28 (315) | File-cutting, Sheffield, 28 Nov. 1900. | - ditto - ditto | 848 | – | 4 | 212 | 2 oil lamps, 2 candles. | 28 Nov. 1900, 5.50 p.m. | — | 45·0 (outside) | 14·4 | ditto | – | – | Fire lit; no other ventilation. | |
| 29 (316) | - ditto - ditto | - ditto - ditto | 1,045 | – | 5 | 209 | 2 oil lamps, 3 candles. | 28 Nov. 1900, 5.35 p.m. | — | ditto | 19·0 | ditto | – | – | Fire lit; one opening 7 in. by 6 in. | |
| 30 (317) | - ditto - ditto | - ditto - ditto | 1,060 | – | 4 | 212 | 2 oil lamps, 2 candles. | 28 Nov. 1900, 6.45 p.m. | — | ditto | 20·7 | ditto | – | – | Fire lit; one louvred opening 9 in. by 4 in. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 31 (318) | - ditto - ditto | - ditto - ditto | 1,080 | – | 5 | 216 | 5 candles. | 28 Nov. 1900, 6.30 p.m. | — | ditto | 19·6 | ditto | – | – | Fire lit; no other ventilation. |
| 32 (319) | File-cutting, Sheffield, 8 Feb. 1901. | - ditto - ditto | 1,152 | – | 4 | 288 | 3 oil lamps. | 8 Feb. 1901, 5.10 p.m. | — | 40·8 (outside) | 15·9 | ditto | – | – | - ditto - ditto. |
| 33 (320) | - ditto - ditto | - ditto - ditto | 932 | – | 4 | 233 | 2 candles, 2 oil lamps. | 8 Feb. 1901, 5.15 p.m. | — | ditto | 18·2 | ditto | – | – | - ditto - ditto. |
| 34 (321) | - ditto - ditto | - ditto - ditto | 674 | – | 2 | 337 | 2 candles. | 8 Feb. 1901, 5.20 p.m. | — | ditto | 14·1 | ditto | – | – | - ditto - ditto. |
| 35 (322) | - ditto - ditto | - ditto - ditto | 942 | – | 3 | 471 | 3 oil lamps. | 8 Feb. 1901, 5.30 p.m. | — | ditto | 17·2 | ditto | – | – | - ditto - ditto. |
| 36 (323) | File-cutting, Sheffield, 15 Feb. 1901. | - ditto - ditto | 400 | – | 4 | 200 | 3 oil lamps, 1 candle. | 15 Feb. 1901, 5 p.m. | — | 36·4 (outside) | 21·2 | ditto | – | – | - ditto - ditto. |
| 37 (324) | - ditto - ditto | - ditto - ditto | 784 | – | 4 | 392 | ditto | 15 Feb. 1901, 5.10 p.m. | — | ditto | 18·1 | ditto | – | – | - ditto - ditto. |
| 38 (325) | - ditto - ditto | - ditto - ditto | 948 | – | 6 | 158 | 1 oil lamp, 4 candles. | 15 Feb. 1901, 5.12 p.m. | — | ditto | 17·9 | ditto | – | – | - ditto - ditto. |
| 39 (326) | - ditto - ditto | - ditto - ditto | 1,215 | – | 5 | 243 | 5 candles. | 15 Feb. 1901, 5.20 p.m. | — | ditto | 19·6 | ditto | – | – | - ditto - ditto. |

TABLE M.

TEXTILE FACTORIES.—COTTON WEAVING (NON-HUMIDIFYING).

| Index No. | Business of Firm, Place, and Date. | Description of Room. | | | Number of Occupants and Space- | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c., per litre of Air. | | Means of Ventilation in actual use at time of Test. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| | | I. | | | | | | | | | | | | | | |
| 1 (327) | Cotton - weaving sheds, Salford, Lancashire, 16 May 1901. | Ground floor, large shed. | 287,820 | 13 | 179 | 1,608 | Daylight. | 16 May 1901, 4.55 p.m. | Taken nearly under one of roof ventilators. | – | 9·2 | 3·5 (Estimate.) | – | – | Roof ventilators at intervals. Windows all closed. | Shed not particularly clean, and air had a musty smell due to "size" probably. |
| 2 (328) | - ditto - ditto | - ditto - ditto | 287,820 | 13 | 179 | 1,608 | ditto | 16 May 1901, 5 p.m. | Another central position. | – | 7·8 | ditto | – | – | - ditto - ditto. | |
| 3 (339) | - ditto - ditto | - ditto - ditto | 287,820 | 13 | 179 | 1,608 | ditto | 16 May 1901, 5.5 p.m. | Same spot - | – | 7·8 | ditto | – | – | - ditto - ditto. | |
| | | II. | | | | | | | | | | | | | | |
| 4 (330) | Same firm - - | Ground floor, small shed adjoining above. | 126,564 | 12 | 59 | 2,145 | ditto | 16 May 1901, 5.10 p.m. | Central position. | – | 6·0 | ditto | – | – | Only slits under roof. | Shed not very clean, and practically no ventilation openings. These tests were taken on a particularly fine, hot day. |
| | | III. | | | | | | | | | | | | | | |
| 5 (331) | Cotton - weaving shed, Preston, 9 Jan. 1902. | Ground - floor, weaving shed (below ground level). | 482,500 | 15 | 283 | 1,705 | ditto | 9 Jan. 1902, 3.35 p.m. | Centre of shed. | – | 10·0 | 4·8 | – | – | Three 24-inch exhaust fans. Roof ventilators closed. | Outside conditions: showery, rather high wind. A large, unhumidified shed, and rather low-lying, purposely so constructed, for the sake of "natural humidity." The ventilation seems to have been uniformly effective, for day and gas light. Air very clear and temperature reasonable. |
| 6 (332) | - ditto - ditto | - ditto - ditto | 482,500 | 15 | 283 | 1,705 | Gas, 297 jets. | 10 Jan. 1902, 5.10 p.m. | Same place next day. | – | 9·6 | 3·0 | – | – | - ditto ditto. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7 (333) | - ditto - ditto | - ditto - ditto | 482,500 | 15 | 283 | 1,705 | Daylight. | 9 Jan. 1902, 3.30 p.m. | Far end of shed. | – | 6·3 | 4·8 | – | – | - ditto - ditto. | |
| 8 (334) | - ditto - ditto | - ditto - ditto | 482,500 | 15 | 283 | 1,705 | Gas, 297 jets. | 10 Jan. 1902, 5.10 p.m. | Same place next day. | – | 9·0 | 3·0 | – | – | - ditto - ditto. | |
| 9 (335) | - ditto - ditto | - ditto - ditto | 482,500 | 15 | 283 | 1,705 | ditto | 10 Jan. 1902, 5.5 p.m. | End near entrance. | – | 10·0 | 3·0 | – | – | - ditto - ditto. | |
| | | IV. | | | | | | | | | | | | | | |
| 10 (326) | Cotton - weaving shed, Bolton, 10 April 1902. | Ground floor, weaving shed. | 532,221 | 15½ | 351 | 1,516 | Daylight. | 19 Apr. 1902, 11 a.m. | Centre of room | 67 | 7·5 | 3·5 (Estimate.) | – | – | Ventilators all closed. | A large, clean, well-kept shed, with saw-back roof. High jacquard looms. Goods very lightly sized. Air seemed fresh and wholesome. |
| | | V. | | | | | | | | | | | | | | |
| 11 (337) | Same firm. Another weaving shed, 9 Jan. 1092. | Ground floor, weaving shed (12 feet below actual ground level). | 359,068 | – | 290 | 1,238 | Gas, 291 jets. | 9 Jan. 1902, 4.30 p.m. | Near centre after dusk. | – | 13·3 | 4·8 | – | – | Two 24-inch exhaust fans, and some small roof ventilation. | In this case, again, the low-level of the shed (12 feet below ground) was said to have some humidifying effect, and artificial humidity was dispensed with. The air appeared to be very clear, even in gaslight, although it might be noted that the gas had not been alight more than 20 minutes or so. The ventilation, as shown by the results, was nothing like so effective as in the last tested similar shed (No. III.) |
| 12 (338) | - ditto - ditto | - ditto - ditto | 359,068 | – | 290 | 1,238 | Daylight. | 11 Jan. 1902, 9.55 a.m. | Same place in daylight. | – | Lost | – | – | – | - ditto - ditto. | |
| 13 (339) | - ditto - ditto | - ditto - ditto | 359,068 | – | 290 | 1,238 | Gas, 291 jets. | 9 Jan. 1902, 4.35 p.m. | End of shed after dusk. | – | 14·0 | 4·8 | – | – | - ditto - ditto. | |
| 14 (340) | - ditto - ditto | - ditto - ditto | 359,068 | – | 290 | 1,238 | Day. light. | 11 Jan. 1902, 10 a.m. | Same place in daylight. | – | 14·8 | 4·6 | – | – | - ditto - ditto. | |
| 15 (341) | - ditto - ditto | - ditto - ditto | 359,068 | – | 290 | 1,238 | Gas, 291 jets. | 9 Jan. 1902, 4.35 p.m. | Far end of shed, 8 feet from wall. | – | 12·5 | 4·8 | – | – | - ditto - ditto. | |
| | | VI. | | | | | | | | | | | | | | |
| 16 (342) | Cotton - weaving shed, Bolton, 10 April 1902. | Ground floor, weaving shed (3 feet below ground level). | 136,884 | – | 96 | 1,425 | E.L., 23 lights on. | 10 April 1902, 9.40 a.m. | One end of shed. | 70 | 6·0 | 3·2 | – | – | Skylights all closed. Stairs open to winding room above. Roof old and not airtight. | Mild, clear and breezy outside. Very old, long, narrow shed, partly a wooden-beamed sawback roof, and partly a fireproof concrete floor to room above. Walls mostly of stone, and also stone floor. Air proved to be remarkably clear of $CO_2$, considering the little ventilation. The room was a few feet below ground level, but was fairly clean, 23 electric lights were kept aglow all day. |
| 17 (343) | - ditto - ditto | - ditto - ditto | 136,884 | – | 96 | 1,425 | ditto | 10 April 1902, 9.45 a.m. | Far end of shed. | 70 | 6·4 | 3·2 | – | – | - ditto . ditto. | |
| 18 (344) | - ditto - ditto | - ditto - ditto | 136,884 | – | 96 | 1,425 | ditto | 10 April 1902, 3.5 p.m. | Bottle sample, centre of shed. | 73 63 | 5·3 | 3·2 | – | – | - ditto - ditto. | |

APPENDIX I.—*continued.*

TABLE M.—*continued.*

| Index No. | Business of Firm. Place, and Date. | Description of Room. Position, Process, &c. | Cubic contents. | Height. | Number of Occupants and Space. Number present. | Space per Person. | Gas, Oil, or Electric Light. | Date, Time and Position of Trust. Date and Time. | Where sampled. | Temperature at same time. | Volumes of $CO_2$ per 10,000. Inside Room. | Outside Air. | Bacteria, &c., per litre of Air. Bacteria. | Moulds. | Means of Ventilation in actual use at time of Test. | REMARKS. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | VII. | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 19 (345) | Same firm, another weaving shed, 10 April 1902. | Ground floor, smaller weaving shed (5 feet below ground level). | 55,176 | – | 38 | 1,425 | E.L. 18 | 10 Apr. 1902, 9.55 a.m. | Centre of shed. | 72 | 5·5 | 3·2 | – | – | All vents closed. Ventilation dependent upon structural crevices in the walls. | Another similar low-lying, narrow room, but covered entirely with concrete ceiling ("doubling mill" above). Stone floor, fairly clean. Goods lightly sized. Steam heated, but not humidified. 18 electric lamps aglow all day. The sort of basement in which one would expect to find the air very much worse than was shown by the results. |
| 20 (346) | - ditto - ditto | - ditto - ditto | 55,176 | – | 38 | 1,425 | ditto | 10 Apr. 1902, 3.10 p.m. | Same place, bottle sample in afternoon. | 73 | 5·0 | 3·2 | – | – | - ditto - ditto. | |
| 21 (347) | - ditto - ditto | - ditto - ditto | 55,176 | – | 38 | 1,425 | ditto | 10 Apr. 1902, 10 a.m. | End remote from door. | 72 | 5·5 | 3·2 | – | – | - ditto - ditto. | |
| | | VIII. | | | | | | | | | | | | | | |
| 22 (348) | Cotton - weaving shed, Blackburn, 15 Jan. 1902. | Ground floor, weaving shed. | 388,800 | 12 | 240 | 1,620 | Daylight. | 15 Jan. 1902, 2.35 p.m. | Centre of shed | 66<br>60½ | 22·8<br>23·6 | 3·5 | – | – | All cowls and trap doors closed. No ventilation. | This was a shed with some features of special interest. The roof was evidently almost airtight. It was covered by an asphalted water tank, extending all over, except for skylights and a few cowl ventilators that were closed for the winter. Internally the shed was very clean, and the air clear from dust. *See* also Nos. 58, 59, Table M. The winter samples having been taken in bottles Dr. Haldane again visited the shed in April to investigate the ventilation more fully by analyses made on the spot. On this occasion the weather was clear, bright, and sunny, after a |
| 23 (349) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | Gas, 295 jets. | 15 Jan. 1902, 4.53 p.m. | Same place, 2¼ hours later. | 69<br>64 | 34·2 | 3·5 | – | – | - ditto - ditto. | |
| 24 (350) | - ditto - ditto | - ditto . ditto | 388,800 | 12 | 240 | 1,620 | Daylight. | 15 Jan. 1902, 2.40 p.m. | Side of shed - | – | 40·8<br>40·8 | 3·5 | – | – | - ditto - ditto. | |
| 25 (351) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | Gas, 295 jets. | 15 Jan. 1902, 4.58 p.m. | Same place, 2¼ hours later. | – | 47·0<br>46·6 | 3·5 | – | – | - ditto - ditto. | |
| 26 (352) | Cotton - weaving shed, Blackburn, 9 April 1902. | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | Daylight. | 9 Apr. 1902, 10.40 a.m. | Centre of shed | 60 | 24·4 | 3·3 | – | – | - ditto - ditto. | |
| 27 (353) | - ditto - ditto | ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 10.45 a.m. | Corner, near warehouse. | 60 | 24·8 | 3·3 | – | – | - ditto - ditto. | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 (354) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 10.50 a.m. | S.W. corner of shed. | 60 | 25·2 | 3·3 | – | – | - ditto - ditto. | frosty morning, with moderate breeze from south-east. Internally the shed was very clean and well kept, but the air decidedly stuffy. The depth of water all over tank was from three to four inches, and the ventilators and skylights were all closed. The first analysis indicated that the $CO_2$ would rise steadily all day in this shed, and this calculation was fully borne out, there being a regular rise in each succeeding analysis, and the afternoon results being higher than the morning ones. (*See* Nos. 26 to 34.) The rate of air supply was apparently only about 220 cubic feet per person per hour. |
| 29 (355) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 11.15 a.m. | Far N.E. corner. | 60 | 25·6 | 3·3 | – | – | - ditto - ditto. | |
| 30 (356) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 11.30 a.m. | S.E. corner - | 60 | 25·6 | 3·3 | – | – | - ditto - ditto. | |
| 31 (357) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 5 p.m. | Far N.E. corner. | 69½ 64½ | 30·8 | 3·3 | – | – | - ditto - ditto. | |
| 32 (358) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 5.10 p.m. | S.W. corner - | 69½ 64½ | 31·2 | 3·3 | – | – | - ditto - ditto. | |
| 33 (359) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 5.15 p.m. | S.E. corner - | 69½ 64½ | 33·0 | 3·3 | – | – | - ditto - ditto. | |
| 34 (360) | - ditto - ditto | - ditto - ditto | 388,800 | 12 | 240 | 1,620 | ditto | 9 Apr. 1902, 5.30 p.m. | Centre of shed | 69½ 64½ | 33·6 | 3·3 | – | – | - ditto - ditto. | |
| | | IX. | | | | | | | | | | | | | | |
| 35 (361) | Cotton - weaving shed, Bolton, 8 April 1902. | Ground floor (large weaving shed). | 460,900 | – | 200 | 2,304 | ditto | 8 Apr. 1902, 3.50 p.m. | - ditto - | – | 12·1 | 3·2 | – | – | Five 15-inch vertical propeller fans, but only one working. Twenty-one large roof cowls closed. | Shed not particularly clean; musty smell. High jacquard looms. Ventilators stopped up for winter, and not yet opened, air consequently unsatisfactory. Shed heated comfortably by steam pipes about 7 feet 6 inches above the ground. |
| 36 (362) | - ditto - ditto | - ditto - ditto | 460,900 | – | 200 | 2,304 | ditto | 8 Apr. 1902, 4 p.m. | Side of shed - | 66 | 11·2 | 3·2 | – | – | - ditto - ditto. | |
| | | X. | | | | | | | | | | | | | | |
| 37 (363) | Same firm, another weaving shed. | Ground floor (small weaving shed, adjoining last). | 201,912 | – | 100 | 2,019 | ditto | 8 Apr. 1902, 4.5 p.m. | Centre of shed | – | 11·8 | 3·2 | – | – | Three 20-inch fans, all stopped. Five large cowls, all closed. | Same remarks apply. |
| | | XI. | | | | | | | | | | | | | | |
| 38 (364) | Cotton - weaving shed, Leigh, Lancashire, 11 April 1902. | Ground floor (weaving shed). | 378,000 | 14 | 219 | 1,726 | ditto | 11 Apr. 1902, 5.56 a.m. | Centre of shed before starting hour. | 45½ | 3·0 | 3·0 | – | – | No ventilators open | Clear, dry, breezy morning; east wind; rather cold after frost; temperature 46° at 10.40 a.m. First test made in early morning before work commenced. Temperature low (45½°). Steam had been off all night, and now just turned on for heating. Rather old shed with stone-paved floor, saw-back roof with wooden beams, and possibly rather porous. Internal conditions clean and wholesome. |
| 39 (365) | - ditto - ditto | - ditto - ditto | 378,000 | 14 | 219 | 1,726 | ditto | 11 Apr. 1902, 8.5 a.m. | Same place, two hours later (breakfast hour). | 49 | 8·8 | 3·0 | – | – | - - ditto. | |

TABLE M.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| | | XI. | | | | | | | | | | | | | | |
| 40 (366) | Cotton weaving shed, Leigh, Lancashire, 11 April 1902. | Ground floor (weaving shed). | 378,000 | 14 | 219 | 1,726 | Daylight. | 11 Apr. 1902, 6 a.m. | Side of shed - | 46 | 3·2 | 3·0 | – | – | No vents open - | A second round of tests was taken just as the engine stopped and the hands were about to leave for breakfast. The temperature had then risen slightly, the $CO_2$ considerably. |
| 41 (367) | - ditto - ditto | ditto - ditto - | 378,000 | 14 | 219 | 1,726 | ditto | 11 Apr. 1902, 8.10 a.m. | Same place, two hours later. | 54 | 7·8 | 3·0 | – | – | - - ditto. | |
| | | XII. | | | | | | | | | | | | | | |
| 42 (368) | Cotton weaving sheds, Bolton, 10 April 1902. | Ground floor, weaving shed (No. 1). | 287,296 | – | 179 | 1,605 | ditto | 10 Apr. 1902, 11.30 a.m. | Centre of shed. | 69 | { 12·4 12·6 } | 3·2 | – | – | Eighteen ventilators in roof, each 12-inch bore, all closed. | Bright and breezy day. This was to all appearances a model shed, one of the most modern and perfect of its kind, clean, light, and lofty, with newly whitened walls and ceiling, and spotless stone floor. Rooms steam-heated, but not humidified. Jacquard looms used for high-class work. Cotton very lightly sized. Iron frame saw-back roof, with glass panes that were supposed to overlap with slight space between (probably stopped up). |
| 43 (369) | - ditto - ditto | - ditto - ditto | 287,296 | – | 179 | 1,605 | ditto | 10 Apr. 1902, 12.25 p.m. | Same place (one hour later). | 69½ | 14·3 | 3·2 | – | – | - ditto - ditto. | |
| 44 (370) | - ditto - ditto | - ditto - ditto | 287,296 | – | 179 | 1,605 | ditto | 10 Apr. 1902, 3.28 p.m. | Same place (four hours later). | 71 | 13·8 | 3·2 | – | – | - ditto - ditto. | |
| | | XIII. | | | | | | | | | | | | | | |
| 45 (371) | Same firm (another shed). | Ground floor, weaving shed (No. 2). | 524,832 | – | 319 | 1,640 | ditto | 10 Apr. 1902, 11.45 a.m. | Centre of room. | 63 | 8·2 | 3·2 | – | – | Similar to above - | A very similar shed in all respects to the above. (All the sheds were rather low-lying). |
| 46 (372) | - ditto - ditto | - ditto - ditto | 524,832 | – | 319 | 1,640 | ditto | 10 Apr. 1902, 3.33 p.m. | Same place (four hours later). | 64 | 14·8 | 3·2 | – | – | - ditto - ditto. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | XIV. | | | | | | | | | | | | | |
| 47 (373) | Same firm (another shed). | Ground floor, weaving shed (No. 3). | 176,176 | – | 141 | 1,249 | ditto | 10 Apr. 1902, 12.15 noon. | Centre of shed. | – | 15·8 | 3·2 | – | – | - ditto - ditto - | Another very similar shed; rather older than the others. |
| | | | XV. | | | | | | | | | | | | | |
| 48 (374) | Same firm (another shed). | Ground floor, weaving shed (No. 4). | 1,016,730 | – | 532 | 1,930 | ditto | 10 Apr. 1902, 12.20 noon. | Centre of room (fans stopped). | – | 16·8 | 3·2 | – | – | Two 30-inch extracting fans, stopped. | This room was the finest of the series, being all newly painted and varnished, and having a capacity of over a million cubic feet. Floors exceedingly clean and roof similar to that of No. 1 shed. The air was shown to be chemically impure, considering that the tests were all made in daylight, with favourable conditions outside. The fan power was misapplied, and inadequate. |
| 49 (375) | - ditto - ditto | - ditto - ditto | 1,016,730 | – | 532 | 1,930 | ditto | 10 Apr. 1902, 3.45 p.m. | Same place (two fans working). | 67½ | 10·8 | 3·2 | – | – | The same fans working. | |
| 50 (376) | - ditto - ditto | - ditto - ditto | 1,016,730 | – | 532 | 1,930 | ditto | 10 Apr. 1902, 3.50 p.m. | Twenty feet from first fan, which had worked 1½ hours, stopped ½ hour, and restarted 10 minutes. | 67½ | 11·0 | 3·2 | – | – | - ditto - ditto. | |
| 51 (377) | - ditto - ditto | - ditto - ditto | 1,016,730 | – | 532 | 1,930 | ditto | 10 Apr. 1902, 3.55 p.m. | Twenty feet from far corner fan, when working. | 67½ | 11·9 | 3·2 | – | – | - ditto - ditto. | |
| 52 (378) | Cotton mills, Preston, 9 Jan. 1902. | Ground floor, winding and warping room (low-lying). | 28,421 | 10 | 39 | 730 | Gas, 48 jets. | 9 Jan. 1902, 4.55 p.m. | Centre of room after dusk. | – | 12·6 | 4·8 | – | – | No ventilators open | This was a very clean, nice-looking room, but the air felt less pure than is shown by the results, especially in gaslight. |
| 53 (379) | - ditto - ditto | - ditto - ditto | 28 421 | 10 | 39 | 730 | Daylight. | 10 Jan. 1902, 3.5 p.m. | Same place next day. | – | 7·5 | 4·6 | – | – | One fanlight slightly open. | |
| 54 (380) | Another cotton mill, Preston, 10 Jan. 1902. | Third floor, winding room. | 67,592 | – | 60 | 1,126 | Gas, 60 jets. | 10 Jan. 1902, 4.15 p.m. | Eight feet from door. | – | 15·4 | 3·0 | – | – | No ventilators open | The weather was chilly and damp, and inside the air seemed to be hot and bad, especially in gaslight, although the results show curiously little difference between gas and daylight. The gas, however, had been lit but a few minutes. |
| 55 (381) | - ditto - ditto | - ditto - ditto | 67,592 | – | 60 | 1,126 | Daylight. | 11 Jan. 1902, 10.20 a.m. | Same place next day. | – | 14 5 | 4·6 | – | – | - ditto - ditto. | |
| 56 (382) | - ditto - ditto | - ditto - ditto | 67,592 | – | 60 | 1,126 | Gas, 60 jets. | 10 Jan. 1902, 4.10 p.m. | Centre of room. | – | 15·6 | 3·0 | – | – | - ditto - ditto. | |
| 57 (383) | - ditto - ditto | - ditto - ditto | 67,592 | – | 60 | 1,126 | Daylight. | 11 Jan. 1902, 10.15 a.m. | Same place next day. | – | 14·0 | 4·6 | – | – | - ditto - ditto. | |

TABLE M.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15). | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 58 (384) | Cotton mill, Blackburn, 15 Jan. 1902. | Ground floor, winding department. | - - | (*See* Remarks) | | - - | Daylight. | 15 Jan. 1902, 2.45 p.m. | Middle of bay | 66 | 28·0 | 3·5 | – | – | No ventilators open | This winding department practically formed a part of the weaving shed described in Table M., Nos. 22 to 34, and all the remarks thereon apply to this part of shed. |
| 59 (385) | - ditto - ditto | - ditto - ditto | – | – | – | – | Gas, 295 jets. | 15 Jan. 1902. 4.50 p.m. | Same place two hours later. | 69 | 36·8 | 3·5 | – | – | - ditto - ditto. | |
| 60 (386) | Cotton mill, Bolton, 16 Jan. 1902 | Ground floor, gassing room. | 25,229 | – | 6 | 5,850 | E.L. and 596 tiny gas jets on machines. | 16 Jan. 1902 3.30 p.m. | One end of room, between gassing machines. | – | 17·8 | 4·0 | – | – | Two 36-inch fans extracting air, and two inlets of corresponding size on opposite side of room. | Air with strong smell of burnt cotton. |
| 61 (387) | - ditto - ditto | - ditto - ditto | 25,229 | – | 6 | 5,850 | ditto | 16 Jan. 1902, 3.33 p.m. | Other end of room, near machines. | – | 12·2 | 4·0 | – | – | - ditto - ditto. | |
| 62 (388) | - ditto - ditto | Ground floor, reeling room. | 35,100 | – | 24 | 1,462 | Daylight. | 16 Jan. 1902, 3.45 p m. | Body of room | – | { 5·7 / 6·2 } | 4·0 | – | – | No ventilation openings. | The air in this room seemed hot, and the amount of $CO_2$ recorded was surprisingly low considering the general conditions. |

TABLE N.

TEXTILE FACTORIES.—COTTON WEAVING (HUMIDIFIED).

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. * | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | I. | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (389) | Cotton cloth factory, Gloucestershire, 28 Nov. 1901. | Ground floor, weaving room (below road level). | 77,775 | $13\frac{1}{12}$ | 51 | 1,523 | Gas, 59 jets, and E L. 12. | 28 Nov. 1901 5.18 p.m. | Middle of room. | 77<br>73 | 8·4 | 2·7 | – | – | All windows closed. Three 15-in. propeller fans on one side and three 15-in. extracting fans on the other. | A dry and fairly mild November afternoon. The action of fans was to some extent thwarted by the valve lids of outlets, which were partially closed through inattention. Possibly the disused fan affected the daylight result. |
| 2 (390) | Cotton cloth factory, Gloucestershire, 29 Nov. 1901. | - ditto - ditto | 77,775 | $13\frac{1}{12}$ | 51 | 1,523 | – | 29 Nov. 1901 4.3 p m. | Body of room (opposite stopped fan). | 75<br>70 | 8·4 | 2·8 | – | – | Same as above, but one extracting fan not working. | |
| 3 (391) | Cotton cloth factory, Gloucestershire, 28 Nov. 1901. | - ditto - ditto | 77,775 | $13\frac{1}{12}$ | 51 | 1,523 | Gas, 59 jets, E L 12. | 28 Nov. 1901 5.20 p.m. | Lower end of room. | 77<br>72 | 16·0 | 2·7 | – | – | Same as above (on 28th). | Same remarks apply. |
| 4 (392) | Cotton cloth factory, Gloucestershire, 29 Nov. 1901. | - ditto - ditto | 77,775 | $13\frac{1}{12}$ | 51 | 1,523 | – | 29 Nov. 1901 4.5 p.m. | - ditto - | 77<br>73 | 7·6 | 2·8 | – | – | Same as above (on 29th). | |
| 5 (393) | - ditto - ditto | - ditto - ditto | 77,775 | $13\frac{1}{12}$ | 51 | 1,523 | E.L. 15. | 29 Nov. 1901 4 p.m. | Top end of room (lighted by electricity). | 75<br>70 | 9·4 | 2·8 | – | – | Same as above (on 29th). | This test was made at the top end of room, where 15 electric lights were being used experimentally, just turned on. |
| | | II. | | | | | | | | | | | | | | |
| 6 (394) | Cotton cloth factory, Gloucestershire, 28 Nov. 1901. | Top floor (2nd) weaving room. | 69,795 | $11\frac{3}{4}$ | 58 | 1,200 | Gas, 70 jets. | 28 Nov. 1901 5.30 p.m. | Lower end of room. | 80<br>74 | 21·8 | 2·7 | – | – | Three 15-in. propeller fans, blowing in air, without corresponding outlets. | The air in this room seemed unpleasant in gaslight and much worse than in the occupied room between this and the ground floor. |

* In this Table's Temperature Column the double figures represent the dry and wet bulb indications.

TABLE N.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | II.—*cont.* | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 7 (395) | Cotton cloth factory, Gloucestershire, 29 Nov. 1901. | Top floor, (2nd) weaving room. | 69,795 | $11\frac{3}{4}$ | 58 | 1,200 | – | 29 Nov. 1901 4.33 p.m. | Lower end of room. | 76 71 | 6·6 | 2·8 | – | – | Three 15-inch propeller fans, blowing air, without corresponding outlets. | |
| 8 (396) | - ditto - ditto | - ditto - ditto | 69,795 | $11\frac{3}{4}$ | 58 | 1,200 | – | 29 Nov. 1901 4.20 p.m. | Body of room | 75 71 | 8·8 | 2·8 | – | – | - ditto - ditto. | |
| 9 (397) | - ditto - ditto | - ditto - ditto | 69,795 | $11\frac{3}{4}$ | 58 | 1,200 | – | 29 Nov. 1901 4.18 p.m. | Top end of room. | 75 71 | 10·6 | 2·8 | – | – | - ditto - ditto. | |
| | | III. | | | | | | | | | | | | | | |
| 10 (398) | Cotton cloth factory, Salford, Lancashire, 16 May, 1901. | Ground floor, cotton weaving shed. | 835,744 | 13 | 793 | 1,053 | – | 16 May 1901, 3 p.m. | Body of shed | 83 67 | 5·5 | 3·5 (Estimate). | – | – | Humidified air blown in by 10 fans. A number of louvred outlets in roof. | Outside conditions: a very fine, hot day. Two very clean, well-arranged sheds undivided. Smoke test on outside of doors showed existence of plenum within, the air escaping outwards at all crevices. The fans were said to be passing 250,000 cubic feet each per hour, and the internal temperature was kept within reasonable limits, considering the great heat of sun on roof. |
| | | IV. | | | | | | | | | | | | | | |
| 11 (399) | Cotton cloth factory, Preston 9 Jan. 1902. | Ground floor, weaving shed. | 185,339 | – | 103 | 1,800 | Gas, 160 jets. | 9 Jan. 1902, 5.15 p.m. | Side of shed after dusk. | $72\frac{1}{2}$ $67\frac{1}{2}$ | 13·6 | 4·8 | – | – | Two impulsion fans. Four 15 inch extracting fans. | A typical humidified shed, in which the ventilation was assisted by the system of humidifying, and the air kept reasonably pure, even in gaslight. The afternoon of 9th was showery and windy, and the next day very wet, and slightly breezy. |
| 12 (400) | - ditto - ditto | - ditto - ditto | 185,339 | – | 103 | 1,800 | Daylight. | 10 Jan. 1902, 3.23 p.m. | Same place next day. | 65 61 | 6·4 | 3·0 | – | – | - ditto - ditto. | |
| 13 (401) | - ditto - ditto | - ditto - ditto | 185,339 | – | 103 | 1,800 | Gas, 160 jets. | 9 Jan. 1902, 5.15 p.m. | Centre after dusk. | 76 $69\frac{1}{2}$ | 15·8 | 4·8 | – | – | - ditto - ditto. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 14 (402) | - ditto - ditto | - ditto - ditto | 185,339 | – | 103 | 1,800 | Day-light. | 10 Jan. 1902, 3.20 p.m. | Same place next day. | – | 4·6 | 3·0 | – | – | - ditto - ditto. | |
| | | V. | | | | | | | | | | | | | | |
| 15 (403) | - ditto - ditto | Ground floor, small weaving shed. | 66,652 | – | 29 | 2,298 | Gas, 44 jets. | 9 Jan. 1902, 5.20 p.m. | Near door after dusk. | 72 68 | – | 4·8 | – | – | One impulsion fan, and one 15 inch extracting fan. | Same remarks apply, except that the ventilation in this shed was not so good. |
| 16 (404) | - ditto - ditto | - ditto - ditto | 66,652 | – | 29 | 2,298 | Day-light. | 10 Jan. 1902, 3.25 p.m. | Same place next day. | 65 62 | 8·2 | 3·0 | – | – | - ditto - ditto. | |
| 17 (405) | - ditto - ditto | - ditto - ditto | 66,652 | – | 29 | 2,298 | Gas, 44 jets. | 9 Jan. 1902, 5.22 p.m. | Far end after dusk. | 73 68 | 20·6 | 4·8 | – | – | - ditto - ditto. | |
| 18 (406) | - ditto - ditto | - ditto - ditto | 66,652 | – | 29 | 2,298 | Day-light. | 10 Jan. 1902, 3.20 p.m. | Same place next day. | 65 61 | 7·8 | 3·0 | – | – | - ditto - ditto. | |
| | | VI. | | | | | | | | | | | | | | |
| 19 (407) | Cotton cloth factory, Preston, 8 Jan. 1902. | Ground floor, large weaving shed. | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 8 Jan. 1902, 4.25 p.m. | Centre of shed after dusk. | 82 71 | 18·4 | 3·7 | – | – | Six plenum humidifying machines (one disabled). Various outlets. | A large, irregularly-shaped shed, fairly well ventilated in daylight, but in gaslight not quite so good. The shed was clean and well kept, and the air fairly clear from dust, &c. Samples were taken under the disabled fan to compare with those taken elsewhere, but there was not much difference except in early morning gaslight. (*See* also remarks below.) |
| 20 (408) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 9 Jan. 1902, 8 a.m. | Same place next morning. | 79 72 | 18·2 | 4·5 | – | – | - ditto - ditto. | |
| 21 (409) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Day-light. | 9 Jan. 1902, 12·5 noon. | Same place noon-day. | 76 69 | 10·4 | 4·5 | – | – | - ditto - ditto. | |
| 22 (410) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 8 Jan. 1902, 4.35 p.m. | Centre of shed under disabled fan. | – | 18·6 | 3·7 | – | – | - ditto - ditto. | |
| 23 (411) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 9 Jan. 1902, 7.56 a.m. | Same place, early morning. | – | 32·0 | 4·5 | – | – | - ditto - ditto. | |
| 24 (412) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Day-light. | 9 Jan. 1902, 12 noon. | Same place, noon-day. | – | 7·4 | 4·8 | – | – | - ditto - ditto. | |
| 25 (413) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 8 Jan. 1902, 4.28 p.m. | End of shed after dusk. | 78 70 | 23·4 | 3·7 | – | – | - ditto - ditto. | |
| 26 (414) | - ditto - ditto | - ditto - ditto | 414,830 | – | 272 | 1,114 | Day-light. | 9 Jan. 1902, 12 noon. | Same place, noon-day. | 73 65 | 7·5 | 4·8 | – | – | - ditto - ditto. | |
| 27 (415) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Gas, 370 jets. | 8 Jan. 1902, 4.42 p.m. | Far side, near wall, 12 ft. from fan. | – | 13·2 | 3·7 | – | – | - ditto - ditto. | |
| 28 416) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | Day-light. | 9 Jan. 1902, 12.5 noon. | Far side. 40 ft. from fan. | – | 7·2 | 4·8 | – | – | - ditto - ditto. | |

APPENDIX I.—*continued.*

TABLE N.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | VI.—*cont.* | *Cubic feet.* | *Feet.* | | | *Cubic feet.* | | | *Degrees.* | | | | | | |
| 29 (417) | Cotton cloth factory, Preston, 8 Jan. 1902. | Ground floor (large weaving shed). | 414,830 | – | 372 | 1,114 | E. L. (all on.) | 15 Jan. 1902, 5.10 p.m. | Far end of shed. | – | 4·9 | 4·4 | – | – | Six plenum humidifying machines (one disabled). Various outlets. (Disabled fan now in use.) | Just a week after the above samples were taken, electric light was substituted for gas in this shed, and the results here shown are indicative of improvement under the new system of lighting; the ventilation and other conditions remaining much as before. |
| 30 (418) | - ditto - ditto | - ditto - ditto | 414,830 | - | 372 | 1,114 | ditto | 15 Jan. 1902, 5 p.m. | Centre of shed. | 78 71 | 14·5 | 4·4 | – | – | - ditto - ditto. | |
| 31 (419) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | ditto | 15 Jan. 1902 5.22 p.m. | End of shed | 72 65 | 9·2 | 4·4 | – | – | - ditto - ditto. | |
| 32 (420) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | ditto | 15 Jan. 1902, 5.15 p.m. | Far side of shed. | – | 15·6 | 4·4 | – | – | - ditto - ditto. | |
| 33 (421) | - ditto - ditto | - ditto - ditto | 414,830 | – | 372 | 1,114 | ditto | 15 Jan. 1902, 5.20 p.m. | Another side of shed. | – | 9·6 | 4·4 | – | – | - ditto - ditto. | |
| | | VII. | | | | | | | | | | | | | | |
| 34 (422) | Another cotton cloth factory, Preston, 10 Jan. 1902. | Ground floor (weaving shed). | 235,000 | – | 154 | 1,526 | Daylight. | 10 Jan. 1902, 3.48 p.m. | Centre of shed | – | 5·2 | 3·0 | – | – | Nine 14-in. extracting fans (one disabled). Inlets not well defined. | Day calm and damp, but no rain. A fairly good well-kept shed, and sufficient ventilation to keep the $CO_2$ within reasonable limits, even in gaslight. It should be noted, however, that the gas, of which there were two jets to each occupant, had not been alight more than 25 minutes or so when the last tests were taken. This, however, was sufficiently long to double the amount of $CO_2$. |
| 35 (423) | - ditto - ditto | - ditto - ditto | 235,000 | – | 154 | 1,526 | 300 gas jets (No. 4 burners) | 10 Jan. 1902, 4.25 p.m. | Same place ¾-hour later. | – | 15·0 | 3·0 | – | – | - ditto - ditto. | |
| 36 (424) | - ditto - ditto | - ditto - ditto | 235,000 | - | 154 | 1,526 | Daylight. | 10 Jan. 1902, 3.45 p.m. | Side of shed, afternoon. | 65 61 | 8·4 | 3·0 | – | – | - ditto - ditto. | |
| 37 (425) | - ditto - ditto | - ditto - ditto | 235,000 | – | 154 | 1,526 | 300 gas jets. | 10 Jan. 1902, 4.25 p.m. | Same place ¾-hour later. | 70 64 | 15·0 | 3·0 | – | – | - ditto - ditto. | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | VIII. | | | | | | | | | | | | | |
| 38 (426) | - ditto - | ditto | First floor, weaving room. | 101,388 | – | 68 | 1,491 | 4 gas jets E.L. 55. | 10 Jan. 1902, 3.50 p.m. | Centre of shed, after dusk. | 74<br>69 | 7·6 | 3·0 | – | – | Three inlet fans—(each 14 inches); also two 14-in. exhaust fans working. Door acts as exit when open. | The air in this room was very clear and good; and it was a very fair sample of what can be done by a system of inlet and exhaust ventilation by mechanical means, especially when combined with electric light. There was no direct communication with the rooms either above or below. |
| 39 (427) | - ditto - | ditto | - ditto - | ditto 101,388 | – | 68 | 1,491 | Daylight. | 11 Jan. 1902, 10.10 a.m. | Same place next morning. | 74<br>70 | 6·6 | 4.6 | – | – | | |
| | | | IX. | | | | | | | | | | | | | |
| 40 (428) | - ditto - | ditto | Second floor, weaving room. | 101,388 | – | 63 | 1,609 | 4 gas jets, E.L. 55. | 10 Jan. 1902, 4 p.m. | Side near door, after dusk. | 76½<br>69½ | 5·3 | 3·0 | – | – | - ditto - ditto - | Same remarks apply, this room being practically similar in all respects to the last. The floors in each case were impervious. |
| 41 (429) | - ditto - | ditto | - ditto - | ditto 101,388 | – | 63 | 1,609 | Daylight. | 11 Jan. 1902, 10.10 a.m. | Sample of air passing out through door. | – | 8·0 | 4.6 | – | – | - ditto - ditto. | |
| 42 (430) | - ditto - | ditto | - ditto - | ditto 101,388 | – | 63 | 1,609 | 4 gas jets, E.L. 55. | 10 Jan. 1902, 4 p.m. | Centre of shed, after dusk. | 73<br>69 | 7·5 | 3·0 | – | – | - ditto - ditto. | |
| 43 (431) | - ditto - | ditto | - ditto - | ditto 101,388 | – | 63 | 1,609 | Daylight. | 11 Jan. 1902, 10.15 a.m. | Same place next morning. | 73<br>69 | 6·6 | 4·6 | – | – | - ditto - ditto. | |
| | | | X. | | | | | | | | | | | | | |
| 44 (432) | Another cotton cloth factory, Preston, 8 Jan. 1902. | | Ground floor, weaving shed (gas-lit portion). | 692,340 | – | 550 | 1,077 | 512 gas jets. | 8 Jan. 1902, 5.25 p.m. | Centre of shed. | 82½<br>73 | 23·0 | 3·7 | – | – | Six plenum humidifying machines. Doors act as exits. | Very heavy rain, mild, no wind. A large oblong shed, well kept and moderately well ventilated in daytime. The air was clear of dust. Range of hygrometer D. 70 to 82½ W. 65 to 73 Part of this shed is lighted by gas and part by electricity, there being no partition between the two, so that the $CO_2$ from the gas passed into the rest of the shed. As samples were in each case taken at morning, noon, and after dusk, it is possible to compare artificial light with daylight (*see* specified times in Col. 9). The outside weather at noonday was bright, mild, and rather windy, but on other occasions was as described above. The electrically illuminated portion is more modern, has higher roof, and much greater air space than the gas-lit portion, but the ventilating power is about the same. It will be seen that the $CO_2$ was higher in the gas-lit portion. The air was clearer, sweeter, and perceptibly cooler in the electric portion. |
| 45 (433) | - ditto - | ditto | - ditto - | ditto 692,340 | – | 550 | 1,077 | ditto | 9 Jan. 1902, 7.43 p.m. | Same place, early morning. | 77<br>68 | 24·6 | 4·5 | – | – | - ditto - ditto. | |
| 46 (434) | - ditto - | ditto | - ditto - | ditto 692,340 | – | 550 | 1,077 | Daylight. | 9 Jan. 1902, 11.30 a.m. | Same place, noonday. | 77<br>69½ | 10·2 | 4·8 | – | – | - ditto - ditto. | |
| 47 (435) | - ditto - | ditto | - ditto - | ditto 692,340 | – | 550 | 1,007 | 512 gas jets. | 8 Jan. 1902, 5.30 p.m. | Far side, after dusk. | 82<br>71 | 29·0<br>29·2 | 3·7 | – | – | - ditto - ditto. | |
| 48 (436) | - ditto - | ditto | - ditto - | ditto 692,340 | – | 550 | 1,077 | ditto | 9 Jan. 1902, 7.46 a.m. | Same place, early morning. | 77½<br>66½ | – | 4·5 | – | – | - ditto - ditto. | |
| 49 (437) | - ditto - | ditto | - ditto - | ditto 692,340 | – | 550 | 1,077 | Daylight. | 9 Jan. 1902. 11.35 a.m. | Same place noonday. | 74<br>68½ | 5·8<br>6·4 | 4·8 | – | – | - ditto - ditto. | |
| | | | XI. | | | | | | | | | | | | | |
| 50 (438) | - ditto - | ditto | Ground floor same shed (portion lighted by electricity). | 402,257 | – | 220 | 1,828 | E.L. 220 | 8 Jan. 1902, 5.25 p.m. | Body of shed, after dusk. | 76<br>68 | 20·6 | 3·7 | – | – | Four plenum humidifying machines. | |
| 51 (439) | - ditto - | ditto | - ditto - | ditto 402,257 | – | 220 | 1,828 | ditto | 9 Jan. 1902, 7.50 a.m. | Same place, early morning. | 72½<br>65 | 18·6 | 4·5 | – | – | - ditto - ditto. | |
| 52 (440) | - ditto - | ditto | - ditto - | ditto 402,257 | – | 220 | 1,828 | Daylight. | 9 Jan. 1902, 11.40 a.m. | Same place, noonday. | 76½<br>68½ | 8·0 | 4·8 | – | – | - ditto - ditto. | |
| 53 (441) | - ditto - | ditto | - ditto - | ditto 402,257 | – | 220 | 1,828 | E.L. 220 | 8 Jan. 1902, 5.30 p.m. | Far side, after dusk. | 76<br>68 | 18·7 | 3·7 | – | – | - ditto - ditto. | |
| 54 (442) | - ditto - | ditto | - ditto - | ditto 402,257 | – | 220 | 1,828 | ditto | 9 Jan. 1902, 7.53 a.m. | Same place, early morning. | 70<br>64 | 11·0 | 4·5 | – | – | - ditto - ditto. | |
| 55 (443) | - ditto - | ditto | - ditto - | ditto 402,257 | – | 220 | 1,828 | Daylight. | 9 Jan. 1902, 11.45 a.m. | Doorway (sample of six passing outwards). | – | 3·8<br>4·0 | 4·8 | – | – | - ditto - ditto. | |

TABLE N.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | XII. | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 56 (444) | Cotton cloth factory, Blackburn, 13 Jan. 1902. | Ground floor, weaving shed. | 424,561 | – | 229 | 1,854 | Gas,343 jets. | 13 Jan. 1902, 5 p.m. | Centre of shed, after dusk, | 58 55 | 12·4 | 3·5 | – | – | Eight 16-inch propeller inlet fans, and nine 14-inch propeller fans for outlet. | Shed humidified by steam jets, and ventilated by both impulsion and extraction, with fairly satisfactory results, even in gas-light, especially considering that gas jets were to occupants as 3 to 2. |
| 57 (445) | - ditto - ditto | - ditto - ditto | 424,561 | – | 229 | 1,854 | Daylight. | 13 Jan. 1902, 2.10 p.m. | End of shed, noonday. | 58 55 | 4·8 | 3·5 | – | – | - ditto - ditto. | |
| 58 (446) | - ditto - ditto | - ditto - ditto | 424,561 | – | 229 | 1,854 | Gas,343 jets. | 13 Jan. 1902, 4.50 p.m. | Same place 2½ hours later. | – | 19·4 | 3·5 | – | – | - ditto - ditto. | |
| | | XIII. | | | | | | | | | | | | | | |
| 59 (447) | Another cotton cloth factory Blackburn, 13 Jan. 1902. | Ground floor, weaving shed. | 739,214 | – | 250 | 2,956 | Daylight. | 13 Jan. 1902, 3.48 p.m. | Side of shed - | 69 64 | 13·2 | 3·5 | – | – | Five plenum humidifying machines. | A large shed, ventilated and humidified on the plenum system, tested both in January and April, the results being much better in the latter case than in the former. |
| 60 (448) | - ditto - ditto | - ditto - ditto | 739,214 | – | 250 | 2,956 | ditto | 9 April, 1902, 12.15 p.m. | Centre of shed, noonday. | 72 65½ | 6·6 | 3·3 | – | – | - ditto - ditto. | |
| 61 (449) | - ditto - ditto | - ditto - ditto | 739,214 | – | 250 | 2,956 | ditto | 9 April 1902, 12.25 p.m. | Side of shed, noonday, | 71 64 | 7·2 | 3·3 | – | – | - ditto - ditto. | |
| | | XIV. | | | | | | | | | | | | | | |
| 62 (450) | Another cotton cloth factory, near Bolton, 17 May 1901. | Ground floor, weaving shed. | 1,348,500 | 14 | 1,000 | 1,348 | Daylight. | 17 May 1901, 10.20 a.m. | About centre of shed. | 73 68 | 8·2 | 3·5 (Estimate). | – | – | Thirteen plenum humidifying machines. | Very fine, warm, and fairly calm day. A large shed, clean and well kept. Air inside was comparatively cool and agreeable. The plenum system appeared to act well, and draughts were not complained of. At central door (wide open) 624,000 cubic feet of air was being discharged per hour, equal to the capacity of two humidifying machines. The $CO_2$ and the temperature were both kept low as a result of this system of ventilation. |
| 63 (451) | - ditto - ditto | - ditto - ditto | 1,348,500 | 14 | 1,000 | 1,348 | ditto | 17 May 1901, 10.20 a.m. | - ditto - | – | 8·8 | ditto | – | – | - ditto - ditto. | |
| 64 (452) | - ditto - ditto | - ditto - ditto | 1,348,500 | 14 | 1,000 | 1,348 | ditto | 17 May 1901, 10.10 a.m. | Another spot in body of room. | 74 68 | 6·4 | ditto | – | – | - ditto - ditto. | |
| 65 (453) | - ditto - ditto | - ditto - ditto | 1,348,500 | 14 | 1,000 | 1,348 | ditto | 17 May 1901, 10.35 a.m. | Near doorway (sample of outgoing air). | 74 68 | 5·4 | ditto | – | – | - ditto - ditto. | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 66 (454) | Another cotton cloth factory weaving shed, Bury, 17 May 1901. | XV. Ground floor, large weaving shed. | 505,212 | 11¾ | 210 | 977 | ditto - | 17 May 1901, 11.20 a.m. | Body of room | 80<br>70 | 6·8 | ditto - | – | | Three plenum humidifying machines. | Very dry, warm day. Shed moderately clean, and steam used in humidifying apparatus is first of all deodorised by a special system, this being rendered necessary on account of the impure river water from which steam is generated. The air coming in through apparatus passed through wet coir mats, and had a temperature of 59° as compared with outer air 66°. |
| 67 (455) | - ditto - ditto | XVI. Ground floor, smaller weaving shed. | 180,180 | 12 | 142 | 1,270 | ditto - | 17 May 1901, 11.45 a.m. | - ditto - | 71<br>65 | – | – | - | – | Same as above. | |
| 68 (456) | Another cotton cloth factory, weaving shed, near Bury, 17 May 1901. | XVII. Ground floor, large weaving shed. | 216,482 | 14 | 188 | 1,151 | ditto - | 17 May 1901, 2.50 p.m. | Central position. | 82<br>76 | 6·0 | 3·5 (Estimate). | - | – | One large humidifying apparatus blowing in air; eight 18-in. extracting fans (some not in full work). A large number of openings from shed to gearing alley, through which air entered. | The system of humidifying is by blowing air by powerful Sturtevant fan through large metal chambers into which steam is sprayed in winter, water in summer; the humidified air then passing through overhead tapering metal trunks, with openings at frequent intervals in shed. The air of shed had a hazy appearance, partly due to the particles of dust rising from material being woven. Floors rather dirty and covered with fluffy dust. Some of the extracting fans were governed in their action by self closing flaps in the outlet, and some of these being overweighted the exit through them was restricted, and the samples taken in the vicinity showed more $CO_2$ than elsewhere. (71 and 72.) |
| 69 (457) | - ditto - ditto | - ditto - ditto | 216,482 | 14 | 188 | 1,151 | ditto - | 17 May 1901, 3.20 p.m. | Same position (½ hour later). | 80<br>74½ | 6·4 | ditto | - | – | | |
| 70 (458) | - ditto - ditto | - ditto - ditto | 216,482 | 14 | 188 | 1,151 | ditto - | 17 May 1901, 3 p.m. | Corner near gearing alley. | – | 3·5 | ditto | - | – | - ditto - ditto. | |
| 71 (459) | - ditto - ditto | ditto - ditto | 216,482 | 14 | 188 | 1,151 | ditto - | 17 May 1901, 3.10 p.m. | Side remote from alley and near over-weighted fan (*see* remarks). | – | 8·2 | ditto | - | – | - ditto - ditto. | |
| 72 (460) | ditto - ditto | - ditto - ditto | 216,482 | 14 | 188 | 1,151 | ditto - | 17 May 1901, 3.15 p.m. | Same position | – | 8·2 | ditto | - | – | - ditto - ditto. | |
| 73 (461) | Another cotton cloth factory, Blackburn, 13 Jan. 1902. | XVIII. Ground floor, large weaving shed. | 203,233 | .. | 108 | 1,881 | Daylight. | 13 Jan. 1902, 2.40 p.m. | Centre of shed | 62⅔<br>60½ | 14·2<br>14·2 | 3·5 | - | – | Six 14-inch extracting fans. Inlets mostly closed. Sheds. | Shed humidified by steam jets, and ventilated by extracting fans without any impulsion. The gas jets considerably outnumbered the occupants. The ventilation, as shown by results, was unsatisfactory, especially in daylight; and a further series of tests were made in April. |
| 74 (462) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | Gas, 168 jets. | 13 Jan. 1902, 5.5 p.m. | Same place, 2½ hours later. | 65<br>61 | 18 8 | 3·5 | - | – | - ditto - ditto. | |
| 75 (463) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | Daylight. | 13 Jan. 1902, 2.42 p.m. | Side of shed - | – | 12·8 | 3·5 | - | – | - ditto - ditto. | |
| 76 (464) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | Gas, 168 jets. | 13 Jan. 1902, 5.10 p.m. | Same place, 2½ hours later. | – | 19·6 | 3·4 | - | – | - ditto - ditto. | |

## APPENDIX I.—*continued.*

TABLE N.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000 | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic Feet.* | *Feet.* | | *Cubic Feet.* | | | | *Degrees.* | | | | | | |
| | | XVIII—*cont.* | | | | | | | | | | | | | | |
| 77 (465) | Same firm, 9 Apr. 1902. | Ground floor, large weaving shed. | 203,233 | – | 108 | 1,881 | Daylight. | 9 Apr. 1902, 3.50 p.m. | Centre of shed | 67½ 64½ | 7·3 | 3·3 | – | – | Six 14-in. ext acting fans; inlets mostly closed (one fan disabled). | An examination of the air grids intended for inlets showed them to be all more or less blocked, the insufficiency of air supply thus caused rendering the fans, to some extent, ineffective. Five minutes after one or two air grids had been cleared, so that air was entering in considerable quantity, the $CO_2$ in worst corner dropped from 10·5 to 9·5. Shed not very clean; walls, ceiling, and floor somewhat dirty. |
| 78 (466) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | ditto | 9 Apr. 1902, 4 p.m. | Another central position. | – | 9·4 | 3·3 | – | – | - ditto - ditto. | |
| 79 (467) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | ditto | 9 Apr. 1902, 4.5 p.m. | Far side, near the stopped fan. | – | 9·6 | 3·3 | – | – | - ditto - diito. | |
| 80 (468) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | | 9 Apr. 1902, 4.10 p.m. | Corner of shed, short distance from entrance. | – | 10·5 | 3·3 | – | – | - ditto - dtito. | |
| 81 (469) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | ditto | 9 Apr. 1902, 4.15 p.m. | Still farther into corner. | – | 10·3 | 3·3 | – | – | - ditto - ditto. | |
| 82 (470) | - ditto - ditto | - ditto - ditto | 203,233 | – | 108 | 1,881 | ditto | 9 Apr. 1902, 4.30 p.m. | Near same corner, five or six minutes after some inlets opened. | – | 9·5 | 3·3 | – | – | For the purposes of this test several air grids in wall were opened, all having previously been blocked. | |
| | | XIX. | | | | | | | | | | | | | | |
| 83 (471) | Another cotton cloth factory, Preston, 11 Jan. 1902. | Ground floor, weaving shed. | 411,600 | – | 250 | 1,646 | ditto | 11 Jan. 1902, 11 a.m. | Centre sf shed | 60 64½ | 7·7 | 4·6 | – | – | Humidifier, with seven 14-inch inlet fans, eight 14-inch extracting fans, all in full work. There were also 12 special tapered inlets in walls, and 116 ventilators distributed over roof with 8-inch outlets. | This shed was particularly well ventilated on the impulsion and extraction principle, the means adopted being both mechanical and "natural." The 12 specially constructed chambered inlets were the invention of the managing director. As a result of such generous ventilation the air was uniformly good, and temperature reasonable. |
| 84 (472) | - ditto - ditto | - ditto - ditto | 411,600 | – | 250 | 1,646 | ditto | 11 Jan. 1902, 11.5 a.m. | One side of shed. | 67 63 | 7·5 | 4·6 | – | – | | |
| 85 (473) | - ditto - ditto | - ditto - ditto | 441,600 | – | 250 | 1,646 | ditto | 11 Jan. 1902, 11.10 a.m. | Side opposite to the above. | – | 8·6 | 4·6 | – | – | | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | XX. | | | | | | | | | | | | | | |
| 86 (474) | Another cotton cloth factory, Blackburn, 15 Jan. 1902. | Ground floor, weaving shed. | 270,038 | – | 128 | 2,109 | Daylight. | 15 Jan. 1902, 3.25 p.m. | Centre of shed. | 65<br>61½ | 6·4 | 3·5 | – | – | One 18-in. and five 14-in. impulsion fans. Four 14-in. exhaust fans. | Shed humidified by steam jets, and satisfactorily ventilated by inlet and outlet fans, especially in daylight. It should be noted that the gas jets were nearly double the number of occupants. The weather was damp, following a morning thaw; getting breezy. |
| 87 (475) | - ditto - ditto | - ditto - ditto | 270,038 | – | 128 | 2,109 | Gas, 202 jets. | 15 Jan. 1902, 5.25 p.m. | Same place, 2 hours later. | 69<br>63 | 16·5 | 3·5 | – | – | - ditto - ditto. | |
| 88 (476) | - ditto - ditto. | - ditto - ditto | 270,038 | – | 128 | 2,109 | Daylight. | 15 Jan. 1902, 3.45 p.m. | Far side of shed. | 59<br>56 | 6·0 | 3·5 | – | – | - ditto - ditto. | |
| 89 (477) | - ditto - ditto | - ditto - ditto | 270,038 | – | 128 | 2,109 | Gas, 202 jets. | 15 Jan. 1902, 5.30 p.m. | Same place, 2 hours later. | 60<br>58 | 18·2 | 3·5 | – | – | - ditto - ditto. | |
| 90 (478) | - ditto - ditto | - ditto - ditto | 270,038 | – | 128 | 2,109 | ditto | 15 Jan. 1902, 5.28 p.m. | Another side of shed. | – | 16·5 | 3·5 | – | – | - ditto - ditto. | |
| | | XXI. | | | | | | | | | | | | | | |
| 91 (479) | Another cotton cloth factory, Blackburn, 9 April 1902. | Ground floor, weaving shed. | 291,435 | – | 155 | 1,880 | Daylight. | 9 Apr. 1902, 1.35 p.m. | Near end of shed. | 71<br>66 | 6·8 | 3·3 | – | – | Nine humidifiers, and six 14-in. impulsion fans. | This shed was humidified on a system of water spraying, air being driven in by small fans through trunks leading from the roof. There were no extracting fans, and the outlets were inadequate. The $CO_2$ results were consequently unequal; low in some parts of shed and high in others. |
| 92 (480) | - ditto - ditto | - ditto - ditto | 291,435 | – | 155 | 1,880 | ditto | 9 Apr. 1902, 1.40 p.m. | Far end of shed. | 72<br>67½ | 11·0 | 3·3 | – | – | - ditto - ditto. | |
| 93 (481) | - ditto - ditto | - ditto - ditto | 291,435 | – | 155 | 1,880 | ditto | 9 Apr. 1902, 2.30 p.m. | Same place, later. | 72<br>67½ | 9·9 | 3·3 | – | – | - ditto - ditto. | |
| 94 (482) | - ditto - ditto | - ditto - ditto | 291,435 | – | 155 | 1,880 | ditto | 9 Apr. 1902, 2.40 p.m. | Centre of shed. | 71<br>66 | 8·8 | 3·3 | – | – | - ditto - ditto. | |
| | | XXII. | | | | | | | | | | | | | | |
| 95 (483) | (Same Firm) - Another cotton cloth factory. | Ground floor, large weaving shed. | 603,151 | – | 298 | 2,000 | ditto | 9 Apr. 1902, 2.45 p.m. | - ditto - | 72<br>65½ | 8·1 | 3·3 | – | – | No note of ventilation. | Shed humidified by steam jets. |
| 96 (484) | - ditto - ditto | - ditto - ditto | 603,151 | – | 298 | 2,000 | ditto | 9 Apr. 1902, 2.50 p.m. | Far side of shed. | 72½<br>65½ | 8·2 | 3·3 | – | – | - ditto - ditto. | |

APPENDIX I.—*continued.*

TABLE O.

TEXTILE FACTORIES.—COTTON-SPINNING.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where Sampled. | | Inside room. | Outside air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (485) | Cotton-spinning mills, Salford, 16 May 1901. | First floor, carding room. | – | – | – | – | – | 16 May 1901, 5.30 p.m. | Body of room | – | 4·1 | 3·5 Estimate). | – | – | Large windows on each side of room, all just closed prior to stopping work. | Very large spinning room, entered just as hands were leaving work at 5.30 p.m. No particulars taken as to space or number of occupants. |
| 2 (486) | Cotton-spinning mills, Bury, 17 May 1901. | Second floor, old building (mule room). | 190,266 | 12 | 16 | 11,888 | – | 17 May 1901, 1 p.m. | - ditto - | 88° | 3·5 | ditto | – | – | Sash windows on each side, some open, cross ventilation. | The cubic space here being enormous, and the weather exceptionally warm and fine, so as to admit of windows being opened, the air inside this factory was equal in purity to that oustide. The heat in the ring room was possibly increased by the main factory chimney going up through the room. |
| 3 (487) | - ditto - ditto | Third floor (top), new building, ring room. | 79,440 | 12 | 32 | 2,482 | – | 17 May 1901, 12.20 noon. | - ditto - | 98·8° | 3·5 | ditto | – | – | One 24-inch fan on side near chimney. Side windows all open, good cross ventilation. | |
| 4 (488) | Cotton-spinning mills, Preston, 8 Jan. 1902. | Fifth floor (top), No. 6 ring room. | 113,850 | 11 | 23 | 4,950 | E. L. 10 | 8 Jan. 1902, 2.55 p.m. | End nearest door. | – | 5·8 | 3·7 | – | – | Door open from stairs, all windows closed. | Weather mild, with drizzling rain at times. A clean, light, well-kept room. First test taken with a few lights on, and second test two hours later with all lights on. |
| 5 (489) | - ditto - ditto | - ditto - ditto | 113,850 | 11 | 23 | 4,950 | E. L. 88 | 8 Jan. 1902, 5 p.m. | End nearest door (second test). | – | 6·0 | 3·7 | – | – | — | |
| 6 (490) | - ditto - ditto | - ditto - ditto | 113,850 | 11 | 23 | 4,950 | E. L. 10 | 8 Jan. 1902, 3 p.m. | Far end of room. | – | 5·2 | 3·7 | – | – | — | |
| 7 (491) | - ditto - ditto | - ditto - ditto | 113,850 | 11 | 23 | 4,950 | E. L. 88 | 8 Jan. 1902, 4.55 p.m. | Far end of room (second test). | – | 5·5 | 3·7 | – | – | — | |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 (492) | - ditto - ditto | Fourth floor, ring room. | 112,701 | 11 | 23 | 4,950 | E.L. 10 | 8 Jan. 1902, 3.6 p.m. | End nearest door. | 94 | 4·4 | 3·7 | – | – | Door open from stairs, seven fanlights open in windows. | General conditions as above. Room very hot, but well ventilated, as the outside temperature admitted of the windows being well opened. |
| 9 (493) | - ditto - ditto | - ditto - ditto | 112,701 | 11 | 23 | 4,950 | E.L. 10 | 8 Jan. 1902, 3.10 p.m. | Far end of room. | 94 | 4·2 | 3·7 | | – | — | The room contained 14 frames with 400 spindles each. |
| 10 (494) | - ditto - ditto | - ditto - ditto | 112,701 | 11 | 23 | 4,950 | E.L. 88 | 8 Jan. 1902, 5.5 p.m. | Far end of room (second test). | – | 4·5 | 3·7 | – | – | Five fanlights only open. | |
| 11 (495) | - ditto ditto | Third floor, ring room. | 102,460 | 10 | 23 | 4,455 | E.L. 10 | 8 Jan. 1902, 3.23 p.m. | End nearest door. | 98 | 4·2 | 3·7 | – | – | One 24-inch centrifugal fan blowing in air through overhead metal tube. Doors open, windows closed. | Room very hot, having regard to the cold weather outside. This room is ordinarily humidified, but the fan intended to blow in moist air could only blow in dry to-day owing to part of apparatus being choked. |
| 12 (496) | - ditto - ditto | - ditto - ditto | 102,460 | 10 | 23 | 4,455 | ditto | 8 Jan. 1902, 3.26 p.m. | Far end of room. | 98 | 4·8 | 3·7 | – | – | | |
| 13 (497) | Another cotton-spinning mill, Preston, 8 Jan. 1902. | Fifth floor (top), ring room. | 32,233 | 9¾ | 12 | 2,696 | – | 8 Jan. 1902, 3.55 p.m. | - ditto - | – | 7·8 | 3·7 | – | – | No ventilation except door from stairs. | A hot room. Tested in afternoon for daylight, and again next morning for gaslight, when 25 jets were actually on and 50 more just turned off. Room had been then occupied 2½ hours. |
| 14 (498) | Another cotton-spinning mill, Preston, 9 Jan. 1902. | - ditto - ditto | 32,233 | 9¾ | 12 | 2,696 | Gas, 25 jets on, 50 just off. | 9 Jan. 1902, 8.28 a.m. | Same place next morning. | – | 17·4 | 4·5 | – | – | | |
| 15 (499) | Another cotton-spinning mill, Preston, 11 Jan. 1902. | Third floor (top), non-humid ring and mule room. | 185,765 | 12 | 40 | 4,644 | – | 11 Jan. 1902, 11.20 a.m. | Centre, between rings and mules. | 88 | 6·4 | 4·6 | – | – | All windows closed. | Room hot. The counts spun were 36$^s$ and 80$^s$. |
| 16 (500) | - ditto - ditto | Second floor, same process. | 185,760 | 12 | 32 | 5,805 | – | 11 Jan. 1902, 11.30 a.m. | - ditto - | – | 8·0 | 4·6 | – | – | Two or three small fanlights open, rest closed. | Similar room to the above. |
| 17 (501) | Another cotton-spinning mill, Blackburn, 13 Jan. 1902. | Ring spinning room. | 94,600 | – | 16 | 5,912 | E.L. 44 | 13 Jan. 1902, 4.5 p.m. | Centre of room. | 80 | 7·7 | 3·5 | – | – | Nil. | |
| 18 (502) | Another cotton-spinning mill, Blackburn, 15 Jan. 1902. | Second floor, mule room (first half). | 80,688 | 12 | 8 | 10,086 | – | 15 Jan. 1902, 3.5 p.m. | Centre of room. | 80 | 8·0 | 3·5 | – | – | Nil. | |
| 19 (503) | - ditto - ditto | - ditto - ditto | 80,688 | 12 | 8 | 10,086 | Gas, 40 jets. | 15 Jan. 1902, 5.6 p.m. | Same place 2 hours later. | – | 13·2 | 3·5 | – | – | Nil. | |

TABLE O.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | *Cubic feet.* | | | | | *Degrees.* | | | | | | |
| 20 (504) | Another cotton-spinning mill, Blackburn, 15 Jan. 1902. | Second floor, mule room (second half). | 88,000 | 12 | 11 | 8,000 | – | 15 Jan. 1902, 3 p.m. | About centre | – | 12·4 | 3·5 | – | – | Nil - - - | This half of the floor seemed to be worse than the other, although the ventilation, &c. was much the same. The gas jets though fewer were larger in size. |
| 21 (505) | - ditto - ditto | - ditto - ditto | 88,000 | 12 | 11 | 8,000 | Gas, 24 large jets. | 15 Jan. 1902, 5.12 p.m. | Same place 2¼ hours later. | – | 17·6 | 3·5 | – | – | Nil. | |
| 22 (506) | Cotton - spinning mills, Bolton, 10 April 1902. | Fourth floor, mule spinning, main room. | – | 14 | 18 | – | – | 10 Apr. 1902, 1.50 p.m. | Centre of room. | 82 | 6·8 | 3·2 | – | – | Nil. 33 windows, but all closed. | An ordinary type of spinning room, medium counts (38s to 58s). The 33 windows were each 7 ft. by 5 ft., but were all closed and a tight fit. |
| 23 (507) | - ditto - ditto | - ditto ditto | – | 14 | 18 | – | – | 10 Apr. 1902, 1.55 p.m. | End of room | 82 | 8·4 | 3·2 | – | – | | |
| 24 (508) | - ditto - ditto | Fourth floor (little end), rings and mules. | – | – | 7 | – | – | 10 Apr. 1902, 1.58 p.m. | Centre of room. | 84 | 5·3 | 3·2 | – | – | Same as above - | Smaller room, higher counts (78s). All fireproof ceilings throughout mill. |
| 25 (509) | - ditto - ditto | Second floor, main room, mule spinning. | – | – | 18 | – | – | 10 Apr. 1902, 2.32 p.m. | - ditto - | 88 | 6·4 | 3·2 | – | – | Nil - - - | Similar room to fourth floor, but immediately over card room. |
| 26 (510) | - ditto - ditto | - ditto - ditto | – | – | 18 | – | – | 10 Apr. 1902, 2.36 p.m. | Far end of room. | 88 | 6·6 | 3 2 | – | – | Nil. | |
| 27 (511) | - ditto - ditto | Third floor, extension, combing room. | – | – | 7 | – | Gas, 2 jets all day. | 10 Apr. 1902, 2.25 p.m. | Centre of room. | – | 6·6 | 3·2 | – | – | None, except crevices. | Room very crowded with machinery, and close over engine house. |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 (512) | Fine cotton-spinning, Bolton, 16 Jan. 1902. | First floor, "main portion," mill spinning, (counts 120s). | 297,880 | – | 33 | 9,026 | – | 16 Jan. 1902, 2.0 p.m. | Centre of room. | 94 | 29·0<br>28·5 | 4·0 | – | – | Practically none. Windows all closed tightly. | The weather in January was raw and damp. In April it was clear, dry, and cold (about 45 degrees). The following tests were made in a large spinning mill, in which the finest "counts" are spun. The rooms were all exceedingly hot, the temperature during the night being maintained by steam pipes. No artificial humidity was in use. The "counts" spun in each room are shown in column 3, and were not always the same for the same room. The walls consist of horned glass windows and brick pillars, the total wall space being about 2,702 square feet, out of which the glass space occupied 1,056 square feet. The windows were tightly glazed, and the walls nearly all painted, rendering the rooms practically air-tight. The pillars consisted of brickwork about 2 feet thick, and the walls under windows were about 1 foot thick. The floors were fire proof, consisting of brick or concrete arches, boarded over. The tests made in winter months were repeated in April, when gaslight had ceased to be used, and it will be seen that the results given by the daylight tests in winter are very much higher than the daylight tests in April, thus showing that the impurities derived from gaslight at the beginning and end of the winter's day were not got rid of during the intervening period of daylight.<br>Considering the enormous cubic space per person, ranging from 30 to 40 times the amount required by Statute, the impurity of the air was particularly remarkable. In nearly all cases the late afternoon results were higher than midday; the one exception being a room in which two small extracting fans were working, showing that a comparatively small outlet was sufficient to keep the $CO_2$ within reasonable limits all day long. On the other hand, where no such outlet existed, the respiratory impurities went on steadily accumulating from morning till evening. |
| 29 (513) | - ditto - ditto | - ditto - ditto | 297,880 | – | 33 | 9,026 | Gas, 110 jets. | 16 Jan. 1902, 4.50. p.m. | Centre of room, 3 hours later. | 98½<br>80½ | 28·6 | 4·0 | – | – | — | |
| 30 (514) | Fine cotton-spinning, Bolton, 8 April 1902. | First floor, "main portion," mill spinning (counts 90s and 130s). | 297,880 | – | 33 | 9,026 | – | 8 April 1902, 12 noon. | Body of room | 88<br>73½ | ·8·3 | 3·0 | – | – | A few very small shutters in window frames, admitting slight quantity of air. | |
| 31 (515) | - ditto - ditto | - ditto - ditto | 297,880 | – | 33 | 9,026 | – | 8 April 1902, 5.28 p.m. | Body of room, 5½ hours later. | – | 14·1 | 2·8 | – | – | - ditto . ditto. | |

## APPENDIX I.—*continued.*

TABLE O.—*continued.*

| Ind ex No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where Sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 32 (516) | Fine cotton-spinning, Bolton, 16 Jan. 1902. | First floor "extension," mule spinning (counts 170s—190s). | 120,919 | – | 12 | 10,076 | – | 16 Jan. 1902, 2 p.m. | Centre of room. | 92<br>76 | 13·8 | 4·0 | – | – | Nil - - - | It will be observed that all the fine spinning is done on self-acting mules, as such spinning cannot be done with rings when the counts are above 100s owing to the weight of the "traveller." Fine spinning cannot be done in a current of air or in a temperature less than 85°, as such a temperature would affect the waxy nature of the fibre. Open windows would blacken the yarn. |
| 33 (517) | - ditto - ditto | - ditto - ditto | 120,919 | – | 12 | 10,076 | Gas, 48 jets. | 16 Jan. 1902, 4.55 p.m. | Centre of room, 3 hours later. | 95<br>79 | 17·6 | 4·0 | – | – | Nil. | |
| 34 (518) | - ditto - ditto | Second floor "main room," mule spinning (counts 166s). | 306,389 | – | 33 | 9,284 | – | 16 Jan. 1902, 2.5 p.m. | Centre of room. | 95 | 12·0 | 4·0 | – | – | Two 15-inch extracting fans working. | The effect of 2 small extracting fans is clearly perceptible in this room; the $CO_2$ registered at all tests comparing favourably with similar tests in other similar but unventilated rooms. In the winter tests, the fans were not powerful enough to check the rise of $CO_2$ due to gaslight, there being 3 gas jets to every person, but in April, the $CO_2$ being due to respiration, could be easily kept within reasonable limits. |
| 35 (519) | - ditto - ditto | - ditto - ditto | 306,389 | – | 33 | 9,284 | Gas, 110 jets. | 16 Jan. 1902, 5.20 p.m. | Centre of room, 3¼ hours later. | 98 | 21·0 | 4·0 | – | – | - ditto - ditto. | |
| 36 (520) | Fine cotton-spinning, Bolton, 8 April 1902. | - ditto - ditto | 306,389 | – | 33 | 9,284 | – | 8 April 1902, 11.10 p.m. | Body of room | 93 | 9·5 | 3·0 | – | – | - ditto - ditto. | |
| 37 (521) | - ditto - ditto | - ditto - ditto | 306,389 | – | 33 | 9,284 | – | 8 April 1902, 5.10 p.m. | Body of room 6 hours later. | – | 8·8 | 2·8 | – | – | - ditto - ditto. | |
| 38 (522) | Fine cotton-spinning mills, Bolton, 16 Jan. 1902 | Second floor "extension," mule spinning (counts 180s and 190s). | 120,542 | – | 12 | 10,045 | – | 16 Jan. 1902, 2.5 p.m. | Centre of room. | 92 | 14·5 | 4·0 | – | – | Nil - - - | In all the rooms under test no gas is used between 31 March and 5 November, so that the summer months are free from its effects. |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 39 (523) | - ditto - ditto | - ditto - ditto | 120,542 | – | 12 | 10,045 | Gas, 48 jets. | 16 Jan. 1902, 5.18 p.m. | Centre of room 3¼ hours later. | 94 | 13·6 | 4·0 | – | – | Nil. |
| 40 (524) | - ditto - ditto | Second floor, "little end," mule spinning (70s to 170s). | 85,535 | – | 9 | 9,504 | Gas, 30 jets, and arc light in one part. | 16 Jan. 1902, 5.25 p.m. | Centre of room. | 94 | 44·4 | 4·0 | – | – | Nil |
| 41 (525) | Fine cotton-spinning mills, Bolton, 8 Apr. 1902. | - ditto - ditto | 85,535 | – | 9 | 9,504 | – | 8 Apr. 1902, 11.0 am. | - ditto - | 90 | 8·8 | 3·0 | – | – | Nil. |
| 42 (526) | - ditto - ditto | - ditto - ditto | 85,535 | – | 9 | 9,504 | Arc light in one part. | 8 Apr. 1902, 5.0 p.m. | Centre of room, 6 hours later. | – | 16·9 | 2·8 | – | – | Nil. |
| 43 (527) | Fine cotton-spinning mills, Bolton, 16 Jan. 1902. | Third floor, "little end," mule spinning (counts 200s). | 91,523 | – | 9 | 10,169 | – | 16 Jan. 1902, 2.30 p.m. | Centre of room. | 92 | 46·2 | 4·0 | – | – | Nil. |
| 44 (528) | - ditto - ditto | - ditto - ditto | 91,523 | – | 9 | 10,169 | Gas, 32 jets, and arc light. | 16 Jan. 1902, 5.5 p.m. | Centre of room, 2½ hours later. | 95<br>82 | 56·6<br>56·3 | 4·0 | – | – | Nil. |
| 45 (529) | Fine cotton-spinning mills, Bolton, 8 Apr. 1902. | Third floor, "little end," mule spinning (counts 186s). | 91,523 | – | 9 | 10,169 | – | 8 Apr. 1902, 11.20 a.m. | Centre of room. | 92 | 12·5 | 3·0 | – | – | Nil. |
| 46 (530) | - ditto - ditto | - ditto - ditto | 91,523 | – | 9 | 10,169 | Arc light in one part. | 8 Apr. 1902, 5.20 p.m. | Centre of room, 6 hours later. | – | 16·5 | 2·8 | – | – | Nil. |
| 47 (531) | Fine cotton-spinning mills, Bolton, 16 Jan. 1902. | Third floor, "main room," mule spinning (counts 120s—160s). | 327,834 | – | 33 | 9,934 | – | 16 Jan. 1902, 2.35 p.m. | Centre of room. | 97½<br>78½ | 15·2 | 4·0 | – | – | Nil |
| 48 (532) | - ditto - ditto | - ditto - ditto | 327,834 | – | 33 | 9,934 | Gas, 110 jets. | 16 Jan. 1903, 5.10 p.m. | Centre of room, 2¾ hours later. | 100½<br>84½ | 27·7 | 4·0 | – | – | Nil. |
| 49 (533) | - ditto - ditto | Third floor, "extension," mule spinning (counts 170s). | 112,053 | – | 12 | 9,337 | – | 16 Jan. 1902, 2.35 p.m. | Centre of room. | 90 | 14·6 | 4·0 | – | – | Nil. |
| 50 (534) | - ditto - ditto | - ditto - ditto | 112,053 | – | 12 | 9,337 | Gas, 48 jets. | 16 Jan. 1902, 5.15 p.m. | Centre of room, 2¾ hours later. | 94 | 20·6 | 4·0 | – | – | Nil. |

For some reason the air in the "ante-room" or "little end" of each floor was much more impure than in the other parts of factory. These rooms were rather darker than the others, and arc lights were used sometimes throughout the day in the darkest corners, but these would be hardly likely to affect the air appreciably.

Some of the finest spinning was done in the third floor "little end," and the air in all seemed oppressive and unpleasant.

From the analysis of 8 April it is evident that the two "little end" rooms were so tight that more than 14 hours were required to effect an average change of the air. For this reason the air would never be pure, even in the early morning.

Although this room was the hottest of the series, the $CO_2$ was not so high as in some of the smaller rooms. It was the largest room in the factory, except the main room on top floor, and the results in these two rooms were very much the same.

APPENDIX I.—*continued.*

TABLE O.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air, | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 51 (535) | Fine cotton spinning, 16 Jan. 1902. | Fourth floor (top), main room, mule spinning (counts 130s.). | 337,133 | – | 33 | 10,216 | – | 16 Jan. 1902, 2.45 p.m. | Centre of room | 92 | 15·5 | 4·0 | – | – | Nil. | |
| 52 (536) | - ditto - ditto | - ditto - ditto | 337,133 | – | 33 | 10,216 | Gas, 110 jets. | 16 Jan. 1902, 4.56 p.m. | Centre of room, 2 hours later. | 96 | 21·8 | 4·0 | – | – | Nil. | |
| 53 (537) | - ditto - ditto | Fourth floor (top) (little end), mule spinning (counts 150s.). | 94,118 | – | 9 | 10,457 | – | 16 Jan. 1902, 3 p.m. | Centre of room | 94<br>78 | 17·8 | 4·0 | – | – | Nil. | |
| 54 (538) | - ditto - ditto | - ditto - ditto | 94,118 | – | 9 | 10,457 | Gas, 30 jets. | 16 Jan. 1902, 4.58 p.m. | Centre of room, 2 hours lat | 98<br>82 | 29·8 | 4·0 | – | – | Nil. | |
| 55 (539) | Fine cotton spinning, 2 Apr. 1902. | Ground floor, combing shed (rather below the) ground level). | 165,118 | 15½ | 34 | 4,856 | – | 8 Apr. 1902, 12.15 noon. | Body of roo | – | 5·3 | 3·0 | – | – | Three 24-in. extracting fans in long wall at side of shed. One 24-in. propeller and one centrifugal fan to roof. A few inlets at intervals in roof. | A very well arranged, clean, well-lighted, and well-ventilated room. The ventilation being chiefly mechanical, and of a powerful character, the air was kept fairly clear from dust, and noticeably pure and fresh as the results show. |
| 56 (540) | - ditto - ditto | - ditto - ditto | 165,118 | 15½ | 34 | 4,856 | – | 8 Apr. 1902, 5.30 p.m. | Body of room, 5¼ hours later. | 71<br>63 | 5·3 | 2·8 | – | – | — | |
| 57 (541) | - ditto - ditto | Ground floor, large "frame room" (rather higher, 5 feet, than combing shed). | 247,212 | 14 | 54 | 4,578 | – | 8 Apr. 1902, 12,30 p.m. | Body of room | 72<br>58½ | 5·5 | 3·0 | – | – | Four 20-in. propeller fans blowing in air on one side of room, and two 24-in. fans extracting air on opposite side of room. The blowing room adjacent also assisted in the extraction of air in this room. | Very well arranged shed. Air slightly dusty, but seemed fresh and wholesome. |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 58 (542) | Cotton-spinning mills, Leigh, Lancashire, 11 April 1902. | Fourth floor (top), mule spinning (counts 50s–70s). | 183,505 | – | 24 | 7,649 | – | 11 Apr. 1902, 6.45 a.m. | Centre of room | 85 | 9·6 | 2·8 | – | – | Nil - - - - | A well-built mill, 22 years old. Specially visited in early morning daylight to compare with later results taken elsewhere. The weather was bright and dry. Cold easterly breeze after frost. The temperature had been maintained all night by steam pipes, the steam being still on. There were 54 windows (each 8 ft. by 6 ft. 6 ins.) all round the room, closed and tight fitting. Considering the very large cubic space per person it is evident that in this and the next room visited the excess of carbonic acid was nearly all due to the previous day's occupation. |
| 59 (543) | - ditto - ditto | - ditto - ditto | 183,505 | – | 24 | 7,649 | – | 11 Apr. 1902, 6.48 a.m. | End of room - | 85 | 7·7 | 2·8 | – | – | Nil. | |
| 60 (544) | Same firm, another mill, 11 April 1902. | Fourth floor (top), mule spinning. | 267,996 | – | 24 | 11,166 | – | 11 Apr. 1902, 6.55 a.m. | Centre of room | 85 | 7·8 | 2·8 | – | – | Nil - - - - | Another modern well-appointed mill, 9 or 10 years old. Steam had been on all night. There were 18 windows (each 16 ft. by 8 ft.) and 20 (each 8 ft. by 6 ft.) of horned glass. This large expanse of glazed windows tends to render the room very hot in summer. |
| 61 (545) | - ditto - ditto | - ditto - ditto | 267,996 | – | 24 | 11,166 | – | 11 Apr. 1902, 7.10 a.m. | Side of room | 85 | 7·0 | 2·8 | – | – | Nil. | |
| 62 (546) | - ditto - ditto | First floor, mule spinning (counts 70s). | 405,880 | – | 48 | 8,456 | – | 11 Apr. 1902, 7.40 a.m. | Middle of room (between inlet and outlet fans). | 90 | 2·8 | 2·8 | – | – | One 30-inch propeller fan with distributing trunk, and one 30-inch extracting fan, both working. | This was a partially ventilated spinning room, which had been recently extended. The old portion was formerly humidified, but now only natural air is driven in on one side, and impure air extracted by mechanical means on the other. Although the temperature here was higher than elsewhere, the air was remarkably pure and fresh, especially near the fans. |
| 63 (547) | - ditto - ditto | - ditto - ditto | 405,880 | – | 48 | 8,456 | – | 11 Apr. 1902, 7.50 a.m. | Extension of room (remote from fans). | 90 | 6·3 | 2·8 | – | | Same as above. | |

## APPENDIX I.—*continued.*

### TABLE O.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 64 (548) | Cotton - spinning mills, Bolton, 8 April 1902. | Third floor, mule spinning (counts 80s). | 224,528 | – | 21 | 10,691 | Daylight. | 8 Apr. 1902, 3 p.m. | Centre of room | 90<br>74 | 10·2 | 3·2 | – | – | Nil - - - - | Weather calm, bright day, temperature 45°. An ordinary spinning room, with concrete ceilings (18 inches deep). Walls, &c. painted and varnished. |
| 65 (549) | - ditto - ditto | Fifth floor (top), mule spinning. | 275,712 | – | 24 | 11,488 | ditto | 8 Apr. 1902, 3.10 p.m. | - ditto - | 85<br>73 | 9·7 | 3·2 | – | – | Nil. | |
| 66 (550) | - ditto - ditto | - ditto - ditto | 275,712 | – | 24 | 11,488 | ditto | 8 Apr. 1902, 3.12 p.m. | - ditto - | 85<br>73 | 10·6 | 3·2 | – | – | Nil. | |
| 67 (551) | Cotton - spinning mills, Bolton, 10 April 1902. | First floor, cotton doubling (immediately over weaving room). | 55,176 | – | 13 | 4,244 | ditto | 10 Apr. 1902, 10.30 a.m. | - ditto - | 85 | 3·7 | 3·2 | – | – | Eight small panes of glass (each 6 in. by 9 in.) open on windward side of room, admitting much air, which was consequently quite fresh. | A clean, well-kept room, and well ventilated by quite ordinary means. The weather was breezy and favourable to ventilation. |
| 68 (552) | - ditto - ditto | - ditto - ditto | 55,176 | – | 13 | 4,244 | ditto | 10 Apr. 1902, 10.35 a.m. | - ditto - | 85 | 3·3 | 3·2 | – | – | | |

TABLE O—*continued.*

TEXTILE FACTORIES.—HUMIDIFIED COTTON-SPINNING.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where Sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 69 (553) | Cotton - spinning mills, Bolton, 10 April 1902. | Third floor, main room, mule spinning (counts 80s—100s). | – | – | 18 | – | – | 10 Apr. 1902, 2 p.m. | Centre of room. | 88<br>75 | 8·0 | 3·2 | – | – | Two small centrifugal high-speed fans and distributors. | An interesting room, being both humidified and ventilated to some extent by a cold water humidifier. Air from outside is drawn in through dripping filters and blown by two small centrifugal fans of very high speed to distributing trunks placed in rows down the room. Although the temperature was higher here and finer counts were spun than in other rooms in the same factory, the air seemed quite as pure, and pleasanter. |
| 70 (554) | - ditto - ditto | - ditto - ditto | – | – | 18 | – | – | 10 Apr. 1902, 2.5 p.m. | Far end of room nearest outside. | 88<br>75 | 8·2 | 3·2 | – | – | Same as above. | |
| 71 (555) | Cotton - spinning mills, Leigh, Lancashire 10 April 1902. | Ground floor, carding and ring spinning (humidified). | 620,759 | – | 100 | 6,207 | – | 11 Apr. 1902, 7.15 a.m. | End of room farthest from humidifier. | 80<br>67 | 2·8 | 2·8 | – | – | A powerful centrifugal fan of high speed working humidifier. Three 30-inch extracting fans on opposite side, also seven vertical tubes down centre of room with openings (12 inch by 9 inch), each 6 feet 6 inches above floor, all open and air entering room in considerable volume. | This room was remarkably well ventilated, as in addition to the fans mentioned it was connected by an open door to the "blowing room," the fans of which assisted to ventilate the carding portion. The air was much cooler than spinning rooms, and as fresh as that outside. |

TABLE O.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 72 (556) | Cotton-spinning mills, Bolton, 8 April 1902 | First floor, mule spinning (counts 80s). | 194,775 | – | 18 | 10,820 | Daylight. | 8 Apr. 1902, 2.15 p.m. | Centre of room. | 85 72 | 11·0 | 3·0 | – | – | Nil - - - - | Rooms humidified by plain water troughs. Walls varnished, fire-proof floors with concrete arches. |
| 73 (557) | - ditto - ditto | Second floor, mule spinning (counts 95s). | 180,810 | – | 18 | 10,043 | ditto | 8 Apr. 1902, 2.30 p.m. | Side of room | 87½ 75 | 10·6 | 3·0 | – | – | Nil. | |
| 74 (558) | - ditto - ditto | - ditto - ditto | 180,810 | – | 18 | 10,043 | ditto | 8 Apr. 1902, 2.35 p.m. | Middle of room. | 87½ 75 | 11·8 | 3·0 | – | – | Nil. | |
| 75 (559) | - ditto - ditto | - ditto - ditto | 180,810 | – | 18 | 10,043 | ditto | 8 Apr. 1902, 2.45 p.m. | - ditto - | 87½ 75 | 9·6 | 3·0 | – | – | Nil. | |
| 76 (560) | - ditto - ditto | - ditto - ditto | 180,810 | – | 13 | 10,043 | ditto | 8 Apr. 1902, 2.50 p.m. | Far side of room. | 87½ 75 | 11·2 | 3·0 | – | – | Nil. | |

TABLE P.

TEXTILE FACTORIES.—WOOL-WEAVING.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c., per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | – | | | *Degrees.* | | | | | | |
| 1 (561) | Woollen weaving shed, Auchterarder, Perthshire, 16 Sept. 1901. | Ground floor, weaving shed. | 472,032 | 16 average. | 201 | 2,350 | – | 16 Sept. 1901, 10.8 a.m. | Centre of shed. | 54 inside, 53 outside. | 5·3 | 2·8 | – | – | 72 cylindrical ventilation pipes in roof, each about 10 inches in diameter, and all open. Door shut. | Series of special tests made by Dr. Haldane to ascertain variations of impurity at different times of the day, and in different parts of a large shed of typical character. Outside conditions—bright day, easterly breeze. The windows of shed facing west, the shed became rapidly warmed by the afternoon sun, and the rise of temperature inside during the afternoon accounted for the increased ventilation as compared with the morning. The easterly breeze doubtless caused the air to be purer on the east side than on the west. Work started at 9 a.m., and during the dinner hour (1 to 2 p.m.) about 100 girls remained in the shed. It will be observed that the inside temperature varied but little from the outside during the morning and middle of day, but that later on in the afternoon the inside temperature rose steadily higher, whilst the outside temperature began to decrease, so that the last record (at 4.17 p.m.) showed a difference between the inside and outside temperature of 18 degrees; this difference coinciding with a decrease in carbonic acid, due to improved ventilation under those conditions. |
| 2 (562) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 10.40 a.m. | - ditto - | 57 inside, 55 outside. | 6·2 | 2·8 | – | – | | |
| 3 (563) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 11.40 a.m. | - ditto - | ditto | 7·3 | 2·8 | – | – | | |
| 4 (564) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 12.20 p.m. | - ditto - | 60 inside. | 6·6 | 2·8 | – | – | | |
| 5 (565) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 12.25 p.m. | - ditto - | ditto | 6·8 | 2·8 | – | – | | |
| 6 (566) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 12.50 p.m. | - ditto - | 61·5 inside, 59·5 outside. | 6·8 | 2·8 | – | – | | |
| 7 (567) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 1.40 p.m. | - ditto - | ditto | 6·4 | 2·8 | – | – | | |
| 8 (568) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 2.0 p.m. | - ditto - | 65 inside. | 4·6 | 2·8 | – | – | | |
| 9 (569) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | - ditto - | - ditto - | ditto | 4·4 | 2·8 | – | – | | |
| 10 (570) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 3.55 p.m. | - ditto - | 73 inside, 57 outside. | 3·7 | 2·8 | – | – | | |

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TABLE P—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 11 (571) | Woollen weaving shed, Auchterarder, Perthshire, 16 Sept. 1901. | Ground floor, weaving shed. | 472,032 | 16 average | 201 | 2,350 | – | 16 Sept. 1901 3.55 p.m | Centre of shed | 73 inside, 57 outside. | 4·2 | 2·8 | – | – | Same as preceding page. | Same as preceding page. |
| 12 (572) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 12.35 p.m. | West side of shed. | 60 | 7·9 | 2·8 | – | – | | |
| 13 (573) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 1.47 p.m. | - ditto - | 61·5 | 7·0 | 2·8 | – | – | | |
| 14 (574) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 4.10 p.m. | - ditto - | 73 | 4·0 | 2·8 | – | – | | |
| 15 (575) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 12.47 p.m. | East side of room. | 60 | 5·0 | 2·8 | – | – | | |
| 16 (576) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 1.55 p.m. | - ditto - | 61·5 | 4·6 | 2·8 | – | – | | |
| 17 (577) | - ditto - ditto | - ditto - ditto | 472,032 | ditto | 201 | 2,350 | – | 16 Sept. 1901, 4.17 p.m. | - ditto - | 75 inside, 57 outside. | 2·7 | 2·8 | – | – | | |
| 18 (578) | Woollen weaving shed, Auchterarder, 30 Dec. 1901. | - ditto - ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 10 a.m. | Centre of shed | 51 inside, 30 outside. | 5·5 | 2·8 | – | – | 72 cylindrical ventilating pipes distributed over roof, each about 10 ins. diameter, 63 of which were closed, leaving 9 only for active ventilation. Doors shut. | Another special series made by Dr. Haldane, in winter months, to compare with that made in September. Outside conditions—cold, but snow melting. Very slight westerly breeze. The shed was heated by steam pipes, and as a consequence the inside temperature was much higher throughout |
| 19 (579) | - ditto - ditto | - ditto - ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 10.38 a.m. | - ditto - | 52 | 6·0 | 2·8 | – | – | | |
| 20 (580) | - ditto - ditto | - ditto - ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 11.15 a.m. | - ditto - | 54 | 6·0 | 2·8 | – | – | | |
| 21 (581) | - ditto - ditto | - ditto - ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 2.20 p.m. | - ditto - | – | 4·8 | 2·8 | – | – | | |

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 22 (582) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 3.35 p.m. | - ditto - | 59 | 6·0 | 2·8 | – | – | the series than that recorded for the outside. This accounted for an improvement of the ventilation in the forenoon, as compared with the summer conditions when the temperatures, internal and external, were nearly equal. This is noteworthy in view of the fact that 6 out of every 7 ventilators were closed during the winter. This series further shows a comparison of the results obtained in daylight and in gaslight at different points of the shed, an interesting feature being that the extra carbonic acid due to lighting of gas had reached its maximum within 45 minutes, and afterwards began to diminish—probably on account of the increased ventilation caused by rise of temperature. The gas was lit at 3.45 to 4 p.m., the burners used being No. 4 Bray's. |
| 23 (583) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | 429 gas jets, lit 3.45 to 4 p.m. | 30 Dec. 1901, 4.35 p.m. | Centre (in gas light). | – | 15·8 | 2·8 | – | – | |
| 24 (584) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | ditto - | 30 Dec. 1901, 4.45 p.m. | - ditto - | – | 14·8 | 2·8 | – | – | |
| 25 (585) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | ditto - | 30 Dec. 1901, 5.10 p.m. | - ditto - | 63·5 inside, 41 outside. | 14·6 | 2·8 | – | – | |
| 26 (586) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 10.30 a.m. | East side (daylight). | 52 inside, 39 outside. | 5·9 | 2·8 | – | – | |
| 27 (587) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 11.30 a.m. | - ditto - | 54 | 6·2 | 2·8 | – | – | |
| 28 (588) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 2.25 p.m. | - ditto - | – | 5·9 | 2·8 | – | – | |
| 29 (589) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 3.20 p.m. | - ditto - | 57 | 5·7 | 2·8 | – | – | |
| 30 (590) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | 429 gas jets. | 30 Dec. 1901, 4.50 p.m. | East side (gaslight), | – | 16·5 | 2·8 | – | – | |
| 31 (591) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | ditto - | 30 Dec. 1901, 5.40 p.m. | - ditto - | 63·5 | 14·2 | 2·8 | – | – | |
| 32 (592) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 10.43 a.m. | West side (daylight). | 53 | 5·4 | 2·8 | – | – | |
| 33 (593) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 11.35 a.m. | - ditto - | 55 | 5·7 | 2·8 | – | – | |
| 34 (594) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 2.35 p.m. | - ditto - | – | 5·1 | 2·8 | – | – | |
| 35 (595) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 2.40 p.m. | - ditto - | 57 inside, 42 outside. | 5·1 | 2·8 | – | – | |
| 36 (596) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | – | 30 Dec. 1901, 3.25 p.m. | - ditto - | – | 6·0 | 2·8 | – | – | |
| 37 (597) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | 429 gas jets. | 30 Dec. 1901, 5 p.m. | West side (gaslight). | – | 14·6 | 2·8 | – | – | |
| 38 (598) | - ditto - | ditto - | ditto - | ditto | 472,032 | ditto - | 184 | 2,560 | ditto - | 30 Dec. 1901, 5.45 p.m. | - ditto - | 63·5 inside, 41 outside. | 14·6 | 2·8 | – | – | |

TABLE Q.

MISCELLANEOUS FACTORIES, &c.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 1 (599) | Surgical appliance making, London, S.E., 10 Jan. 1901. | Basement (low ceiling), machine braiding. | 9,565 | 8 | 15 | 637 | E. L. (all on). | 10 Jan. 1901, 5 p.m. | Near inlets | – | ·2 | 3·5 (Estimate). | – | – | Two inlets, 20 in. by 30 in., from street at pavement level. Two outlets, 14 in. by 28 in., at innermost end (to room above). | Referred to the Committee as a bad example of a basement workroom. In this and other instances of suspected basements, however, the impurity recorded was not so great as supposed. |
| 2 (600) | - ditto - ditto | - ditto - ditto | 9,565 | 8 | 15 | 637 | ditto | 10 Jan. 1901, 5.5 p.m. | Near outlets | – | 11·0 | ditto. | – | – | Same as above. | |
| 3 (601) | - ditto - ditto | Second floor, elastic-web weaving. | 4,254 | 9 | 6 | 709 | E. L. and gas (5 jets). | 10 Jan. 1901, 5.30 p.m. | Body of room | – | 10·1 | ditto. | – | – | Windows slightly open : stairs above and below. | |
| 4 (602) | Horse clothing, London, S.W., 9 Oct. 1901. | First floor, women's sewing room. | 42,294 | 10½ | 71 | 595 | Gas (42 jets) in three rows. | 9 Oct. 1901, 4.35 p.m. | Body of room at breathing level. | – | 7·8 | ditto | – | – | Seven windows (each 5 ft. 6 in. by 5 ft. 6 in.) with casements open wide. Four outlet tubes (18 in. by 9 in.), with orifice near ceiling also open. | Referred to the Committee as an example of a badly arranged and badly ventilated workshop. The arrangement was not altogether satisfactory, but with so many windows open wide the air did not on this occasion prove to be relatively impure, in spite of the fact that gas had been burning practically all day. |
| 5 (603) | - ditto - ditto | - ditto - ditto | 42,294 | 10½ | 71 | 595 | ditto | 9 Oct. 1901, 4.45 p.m. | Taken near orifice of outlet tube just under ceiling. | – | 11·0 | ditto. | – | – | - - | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (604) | Manufacture of incandescent gas mantles, London, S.W., 10 Oct. 1901. | Ground floor, women's department. | 24,192 | 14 | 74 | 327 | Incan. gas (7 jets), also 40 under process. | 10 Oct. 1901, 5.45 p.m. | Body of room | – | 8·8 | ditto. | – | – | One 30-in. exhaust fan near ceiling (about 12 feet from floor). Sundry inlets on opposite sides of room. | Referred to the Committee as an interesting case, and one of few non-textile factories visited in which mechanical ventilation was used. Room very clean and floors disinfected twice daily with fluid over sawdust. |
| (605) | - ditto - ditto | - ditto - ditto | 24,192 | 14 | 74 | 327 | ditto | 10 Oct. 1901, 6.20 p.m. | Taken through trapdoor in discharge trunk from fan. | – | 10 0 | ditto. | – | – | | |
| (606) | Brush works, Bristol, 22 Mar. 1902. | Second floor (top), pan room. | 22,140 | 12 | 37 | 598 | 6 gas pan heating rings. | 22 Mar. 1902, 11.40 a.m. | End of room near stairs. | 53 | 5·7 | 3·1 | – | – | Two Dormer windows open. One shallow louvre and one small fanlight in roof. Three grids in floor covered. | Referred to the Committee as a specific case of bad ventilation and deficient heating arrangements. Pitch fumes are given off from the "pans," and the air was rather thick and clouded. The windows were all closed, except those shown in Col. 16. There were three grids in floor to admit air from occupied room below, but these were covered. On removing cover from centre grid it was found that air came through at a velocity of 260 feet per minute. The room was not fully occupied, but six out of seven pans were in use. Ceiling rather discoloured with pitch smoke, but room otherwise clean and satisfactory. Heating apparatus some weeks out of repair and disused. Temperature consequently low (53°). Apart from the fumes the ventilation could not be said to be unsatisfactory. The outside conditions were favourable, the weather being breezy and sunny. |
| 9 (607) | - ditto - ditto | - ditto - ditto | 22,140 | 12 | 37 | 598 | ditto - | 22 Mar. 1902, 11.43 a.m. | Middle of room near pans. | 53 | 8·6 | 3·1 | – | – | | |
| 10 (608) | - ditto - ditto | - ditto - ditto | 22,140 | 12 | 37 | 598 | ditto - | 22 Mar. 1902, 11.45 a.m. | Far end of room near other pans. | 53 | 7·4 | 3·1 | – | – | | |
| 11 (609) | - ditto - ditto | - ditto - ditto | 22,140 | 12 | 37 | 598 | ditto - | 22 Mar. 1902, 11.50 a.m. | Taken just over grid leading from floor below. | 53 | 10·3 | 3·1 | – | – | | |
| 12 (610) | - ditto - ditto | First floor, "stock" room (woodworking machinery, &c.). | 18,450 | 10 | 20 | 922 | – | 22 Mar. 1902, 12 noon. | Occupied end of room (far end). | 53 | 5·5 | 3·1 | – | – | No ventilation except door, and one grid to floor above, the windows being closed. | A long narrow room, rather dusty, but fairly clean. The end nearest stairs was taken up with piles of wood; the far end occupied with workers. Curiously, the air was found least pure at unoccupied end, a point not infrequently observed in other similar tests. |
| 13 (611) | - ditto - ditto | - ditto - ditto | 18,450 | 10 | 20 | 922 | – | 22 Mar. 1902, 12.5 noon. | Unoccupied end of room near stairs. | 53 | 7·2 | 3·1 | – | – | | |

## APPENDIX I.—*continued.*

TABLE Q.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 14 (612) | Ropemaking, Chatham, 31 May 1901. | First floor, flax spinning room. | Not recorded, but ample space per person. | | | | Daylight. | 31 May 1901, 3.30 p.m. | Near one of the "drawing frames" | – | Not recorded, but estimated at 3·0 | 3·0 | 20 | 6 | One large centrifugal exhaust fan with metal trunk extending over centre of room, and branching out to drawing frames (some dampers closed). Also five large (42-in.) propeller fans on one side of room, and one of same size on opposite side, all extracting. Speed 720 revolutions per minute. As several large windows were wide open near the fans some of the latter were rendered less effective by short circuiting. | This was a large room provided with enough fan power to be thoroughly ventilated if some of it had not been misapplied or badly arranged. As it was the general effect was to keep the dust in suspension rather than to expel it from the room. Although there must have been an abundant supply of fresh air drawn in from outside, the inside air of room was in some places exceedingly dusty, and in the dustiest places samples of air submitted to bacteriological tests gave higher results than any other places visited by the Committee. The weather was very warm, sunny, and slightly breezy, conditions favourable to ventilation. |
| 15 (613) | - ditto - ditto | - ditto - ditto | – | – | – | – | – | 31 May 1901, 3.45 p.m. | At a dustier place. | – | – | – | 82 | 8 | | |
| 16 (614) | - ditto - ditto | - ditto - ditto | – | – | – | – | – | 31 May 1901, 4 p.m. | At a very dusty place. | – | – | – | 850 (approximate.) | 18 | | |

TABLE Q.—*continued.*

MISCELLANEOUS PLACES.

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time, and Position of Trust. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| | Large public hall (Provincial), 14 Nov. 1901. | — | – | – | – | – | – | – | – | – | – | – | – | – | — | For purposes of comparison this series of observations was made at a large provincial hall on a day in November 1901, when a popular flower show had been in progress all the day, and the hall was thickly crowded with 4,000 or 5,000 people. Most of these were promenading, the seating accommodation in many places having been temporarily removed. Clear, dry, cold day (about 36°) tending to frost, which afterwards became very keen. |
| 17 (615) | - ditto - ditto | Ground floor - | – | – | – | – | E.L. (all on) | 14 Nov. 1901, 7.30 p.m. | Just in front of orchestra but on a lower level, About 30 ft. from nearest wall. | 66 (Estimated.) | 20·0 | 3·3 | – | – | All windows appeared closed. No mechanical ventilation could be seen, heard or felt at any part of building. One large circular air grid in roof over orchestra. Doors open—people going and coming. | This point was perhaps the most thickly occupied centre in the building, there being slowly moving crowds on every hand. The air seemed dense, dusty, warm and motionless, but not so hot and suffocating as in the galleries overhead. |

TABLE Q.—*continued.*

| Index No. | Business of Firm, Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 18 (616) | Large public hall (Provincial), 14 Nov. 1901. | Ground floor | – | – | – | – | E.L. (all on | 14 Nov. 1901, 9.18 p.m. | Same spot 1¾ hours later. | – | 14·2 | 3·3 | – | – | All windows appeared closed. No mechanical ventilation could be seen, heard or felt at any part of building. One large circular air grid in roof over orchestra. Doors open, people going and coming. | The crowd was still dense when this second test was taken, but was beginning to thin. People leaving to catch trains, &c. Outside doors open—some draughts of cool air occasionally felt. |
| 19 (617) | - ditto | - ditto | - ditto | – | – | – | – | ditto | 14 Nov. 1901, 7.35 p.m. | Just in under the "president's gallery" at opposite end to orchestra. | – | 19·6 | 3·3 | – | – | ditto - ditto - | This part of ground floor was not so thickly occupied; crowd only about 60 per cent. of that at opposite end (near orchestra). Air seemed warm, but not so stuffy as elsewhere. |
| 20 (618) | - ditto | - ditto | - ditto | – | – | – | – | ditto | 14 Nov. 1901, 9.25 p.m. | Same spot 50 minutes later. | – | 18·2 | 3·3 | – | – | - ditto - ditto - | Crowd lessening at second test. Outside doors open—cooler than before. Some draughts from doors. As in most other cases coming under the Committee's observation, where a direct communication existed between the ground floor and higher levels, the $CO_2$ on the former was very much the lower. |

| | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6665. M | 21 (619) | - ditto | ditto - | First floor gallery. (*See* remarks.) | – | – | – | – | – | 14 Nov. 1901. 7.45 p.m. | Left hand side of west gallery. Orchestra end six or eight feet from wall. | About 70 | 30·4 | 3·3 | – | – | Two large circular air grids in ceiling, one at orchestra end and one at extreme end of gallery. Doors continually opening and shutting. | This was a slanting gallery perhaps about 12 to 20 feet above ground floor, ranging all round the hall except at orchestra end. About 14 feet from back to front, and quite open to central hall. Another gallery immediately above. Crowded and very warm. People slowly drifting along in front of exhibits. |
| | 22 (620) | - ditto | ditto - | - ditto | - ditto | – | – | – | – | | 14 Nov. 1901, 9.10 p.m. | Same spot, 1½ hours later. | – | 44·4<br>44·4 | 3·3 | – | – | - ditto ditto - | More people going out at 2nd test, but still very full. This sample of air was taken at a congested point in the slowly moving crowd, and the $CO_2$ does not perhaps represent the average degree of impurity so accurately as in the previous test. |
| | 23 (621) | - ditto | ditto - | Second floor gallery (top). (*See* remarks.) | – | – | | – | – | 14 Nov. 1901, 8.5 p.m. | Position similar to the above, only one storey higher. | – | 39·4 | 3·3 | – | – | - ditto ditto - | This gallery was very similar in construction and position to the one below, only much higher (say 25 to 35 feet above ground floor). At the end where this test was taken the gallery was only half full. No promenading, people mostly standing. Air very hot and motionless, rather "suffocating" in places. |
| | 24 (622) | - ditto | ditto - | . ditto | . ditto | – | – | – | – | – | 14 Nov. 1901, 9 p.m. | Same spot, one hour later. | – | 39·6 | 3·3 | – | – | - ditto ditto - | Rather more people here at 2nd test, moving towards doorway. Air still motionless and stuffy, but not quite so bad as before. |

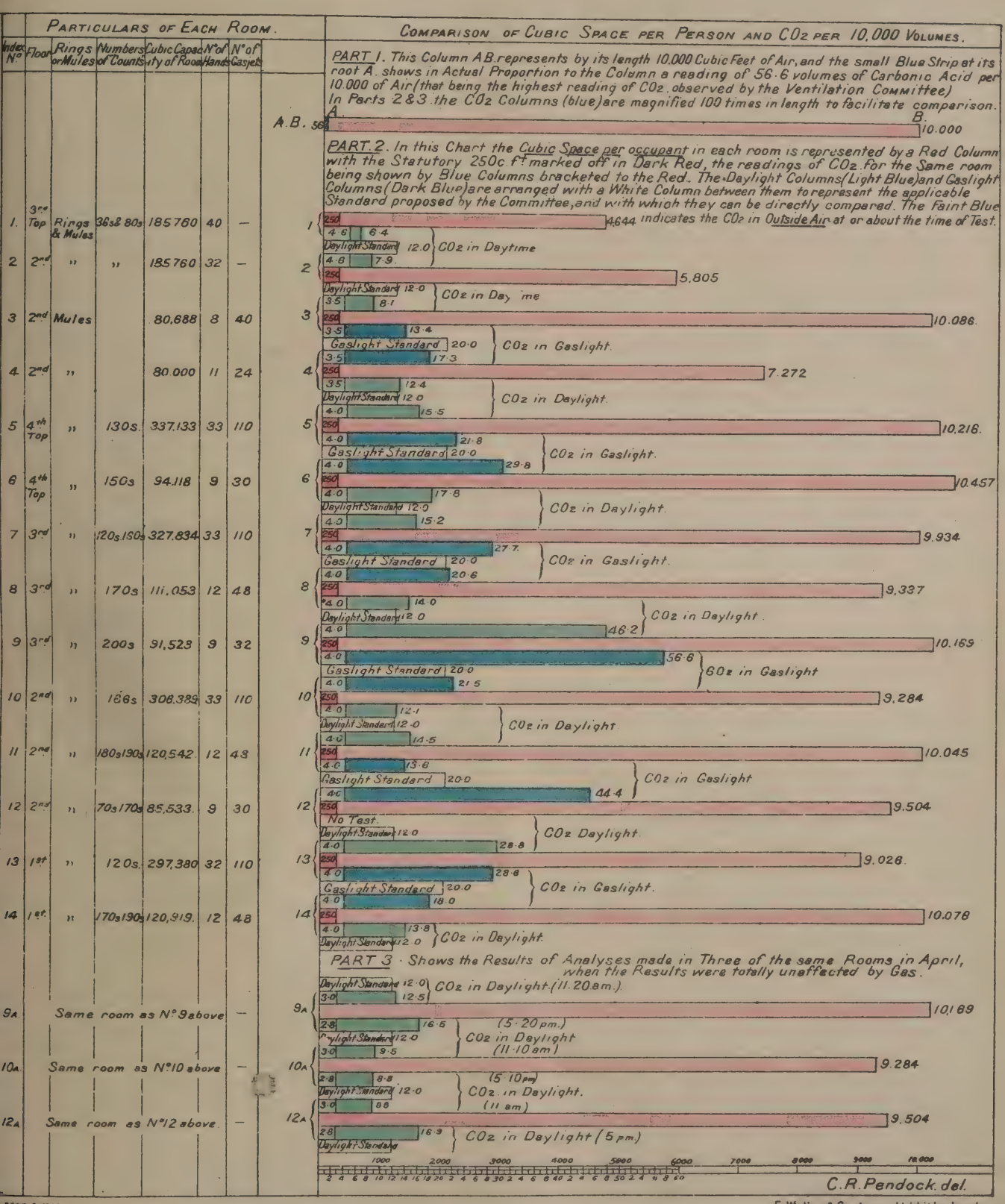
## APPENDIX I.—*continued.*

TABLE Q.—*continued.*

| Index No. | Business of Firm Place and Date. | Description of Room. | | | Number of Occupants and Space. | | Gas, Oil, or Electric Light. | Date, Time and Position of Test. | | Temperature at same time. | Volumes of $CO_2$ per 10,000. | | Bacteria, &c. per litre of Air. | | Means of Ventilation in actual use at time of Test. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Position, Process, &c. | Cubic contents. | Height. | Number present. | Space per Person. | | Date and Time. | Where sampled. | | Inside Room. | Outside Air. | Bacteria. | Moulds. | | |
| (1.) | (2.) | (3.) | (4.) | (5.) | (6.) | (7.) | (8.) | (9.) | (10.) | (11.) | (12.) | (13.) | (14.) | (15.) | (16.) | (17.) |
| | | | *Cubic feet.* | *Feet.* | | *Cubic feet.* | | | | *Degrees.* | | | | | | |
| 25 (623) | Large public hall (Provincial), 14 Nov. 1901. | Second floor gallery (top). (*See* remarks.) | – | – | – | – | – | 14 Nov. 1901, 9.5 p.m. | Far end of west gallery, and the highest occupied point. | – | 38·5 | 3·3 | – | – | One of the ceiling air grids was just over this part of gallery. | This test was taken at the extreme opposite end of same gallery, and the highest occupied point in the hall. Most crowded part of gallery. Air very hot, motionless and "suffocating," some ladies nearly fainting. Audience had just risen at end of stage performance when sample taken, but very few gone out. |
| 26 (624) | - ditto ditto - | Large orchestra. A steep gallery surrounding organ rising from about six feet [illegible]h at rostrum to 30 feet at back. | – | – | About 400 | – | E.L. (All on). | 14 Nov. 1901 | About middle of orchestra between band and organ. | – | 38·6 | 3·3 | – | – | One of the large circular air grids in ceiling was just above the orchestra. | The orchestra had been largely occupied by spectators all evening (probably 650 in addition to the band), but nearly half had left before this sample was taken. |

# Chart I. Analyses of Air from Some large Cotton Spinning Rooms (Table O).

## Graphic Comparison of Cubic Space and $CO_2$ Results.





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# APPENDIX II.

## General Account of the Conditions of Efficient Ventilation.

# APPENDIX II.

Contents.

# APPENDIX II.

## GENERAL ACCOUNT OF THE CONDITIONS OF EFFICIENT VENTILATION.

The present Appendix contains an account of the conditions which render general ventilation necessary in factories and workshops, and of the means by which general ventilation is brought about.

### Composition of Atmospheric Air in the Country and in Towns.

Pure atmospheric air free from aqueous vapour has the following composition by volume :—

| | |
|---|---|
| Oxygen | 20·94 |
| Nitrogen | 78·09 |
| Argon | 0·94 |
| Carbonic Acid | 0·03 |
| Helium, Krypton, Neon, Xenon, and Hydrogen | Traces. |
| | 100·00 |

So far as known this composition is not sensibly departed from at any part of the earth's surface, apart from the purely local influence of combustion, etc.

In connection with questions of ventilation a special interest attaches to the exact proportion of carbonic acid ($CO_2$) in pure air. The older determinations by Pettenkofer's method gave results which varied considerably according to the particular manipulations employed by different observers, and were usually too high by about 0·5 volumes per 10,000 of air, though occasionally also a good deal too low. Recent determinations by more exact methods show that apart from the influence of vegetation, &c., pure air when dry contains almost exactly 3·0 volumes per 10,000. In summer weather the proportion may rise to about 3·5 volumes by night, or fall to 2·6 volumes by day, in the lower strata of the air, in consequence of the influence of vegetation.

The following table shows the average results of a series of exact determinations of carbonic acid in country air in Scotland*.

| — | | Vols. of $CO_2$ per 10,000. | | | | |
|---|---|---|---|---|---|---|
| | | No. of analyses | Maximum. | Minimum. | Average. | |
| April 1—September 30 | Day | 29 | 3·11 | 2·58 | 2·88 | 2·98 |
| | Night | 22 | 3·55 | 2·82 | 3·08 | |
| December—January | Day | 6 | 3·12 | 2·93 | 2·99 | 3·00 |
| | Night | 5 | 3·06 | 2·94 | 3·01 | |

Almost exactly the same average results were previously obtained in France by Reiset, who absorbed the carbonic acid with baryta water, and used 525 litres of air for each determination (Annales de Chimie et de Physique, Vol. 26, 1882, p.198). The mean of 220 experiments made in 1872–1880 gave 2·96 volumes.

In towns the atmosphere is slightly altered in composition through the great combustion of fuel. In clear weather or in summer, the alteration on the figures just given is very slight. In fogs, however, there is a very definite rise in the percentage of carbonic acid, accompanied, doubtless, by a slightly greater fall in the oxygen

* These analyses, which have not hitherto been published, were made by J.S. Haldane and E.S. Haldane in 1889–90 by the gravimetric method of Haldane and Pembrey (Philosophical Magazine 1890, p.306.); 76·7 litres of air were aspirated for each experiment. The results are corrected for temperature, barometric pressure and aqueous vapour. The samples were taken at 4 feet from the ground on the northern slope of the Ochill hills, near Auchterarder, Perthshire.

## Appendix II.—*continued.*

percentage. In a sample of London air collected at St. Bartholmew's Hospital Dr. Russell* on one occasion found as much as 14 volumes per 10,000 of carbonic acid in the outside air during a very dense and prolonged fog. Where the proportion of carbonic acid is used as a test of sufficient ventilation of rooms it is evidently of practical importance to know the extent to which the proportion of carbonic acid in the air of towns is liable to rise. The following table shows the average results of Dr. Russell's analyses by Pettenkofer's method of outside air in the centre of London (at St. Bartholomew's Hospital) during the years 1882, 1883, 1884.

| | Vols. of $CO_2$ per 10,000. | | | |
|---|---|---|---|---|
| | No. of analyses | Maximum. | Minimum. | Average. |
| April—September | 92 | 4·8 | 3·0 | 3·81 } 4·01 |
| October—March | 40 | 6·4 | 3·2 | 4·22 } |

These averages are exclusive of results obtained during fogs. They show that the average proportion of carbonic acid is about 0·4 volumes higher in winter than in summer, and at all seasons higher than in country air. As, however, the analyses were made by Pettenkofer's method it is probable that the averages are about 0·5 volumes too high, so that 3·3 and 3·7 are more probable averages.

The following table shows the results obtained at St. Bartholomew's Hospital by Dr. Russell during fogs.

| Date. | Weather. | Temperature. | | Barometer in mm. | Direction of Wind. | Vols. of $CO_2$ in 10,000 of Air. |
|---|---|---|---|---|---|---|
| | | Wet Bulb. | Dry Bulb. | | | |
| 1882. | | | | | | |
| Jan. 17 | Dense black fog | — | 10·0 | 786 | S. | 6·7 |
| „ 18 | Dense black fog | — | 4·0 | 786 | S. | 5.7 |
| „ 19 | Slight white fog | — | 6·0 | 768 | S. | 4·8 |
| „ 25 | Dense black fog | — | 3·5 | 780 | S. | 10·5 |
| Feb. 3 | Slight fog | 3·0 | 4·4 | 781 | S. | 6·9 |
| „ 4 | Dense black fog | 4·3 | 5·0 | 785 | S. | 10·7 |
| March 15 | Slight white fog | 9·0 | 11·0 | 775 | N.E. | 5·6 |
| Oct. 26 | White fog | 0·6 | 7·7 | 750 | W. | 9·9 |
| Nov. 18 | Dense black fog | 2·2 | 2·7 | 760 | S.E. | 9·6 |
| Dec. 1 | Thick white fog | 1·6 | 2·2 | 765 | S. | 5·5 |
| „ 2 | Slight mist | 1·1 | 1·6 | 766 | S.E. | 5·1 |
| „ 10 | Thick white fog | 0·5 | 1·1 | 755 | S.W. | 9·4 |
| „ 11 | Thick white fog, darker, noon | — | 0·5 | 755 | S.W. | 11·0 |
| „ 11 | Thick white fog, very dark, 5 p.m. | — | 0·5 | 755 | S.W. | 14·1 |
| „ 14 | White fog, slight | 4·4 | 4·4 | 755 | S.E. | 6·2 |
| „ 15 | White fog, slight | 5·0 | 6·1 | 753 | S.E. | 5·4 |
| „ 15 | Overhead fog, white | 3·3 | 4·4 | 760 | S.E. | 4·8 |
| „ 20 | Dense black fog | 4·4 | 4·7 | 767 | S. | 8·1 |
| 1883. | | | | | | |
| Jan. 19 | Slight fog | — | 8·8 | 763 | S.W. | 5·0 |
| April 3 | Fog, dense | 10·0 | 12·2 | 762 | W. | 13·3 |
| „ 8 | Slight white fog | 7·7 | 11·1 | 756 | S.E. | 4·7 |
| Oct. 10 | Slight yellow fog | 12·2 | 13·8 | 760 | N.W. | 4·5 |
| „ 11 | Dense black fog | 11·6 | 12·7 | 758 | S.E. | 7·6 |
| Nov. 15 | Slight yellow fog | 5·5 | 7·7 | 761 | W. | 6·6 |
| 1884. | | | | | | |
| Jan. 16 | Slight yellow fog | 6·1 | 7·2 | 776 | N.W. | 5·5 |
| „ 18 | Slight fog | 6·6 | 8·3 | 775 | S.W. | 4·5 |
| Feb. 8 | Black fog | 6·1 | 7·7 | 747 | S.E. | 5·5 |
| April 27 | Overhead fog | 7·2 | 8·3 | 754 | S.E. | 5·3 |
| „ 28 | Yellowish fog, slight | 8·8 | 10·0 | 753 | S.E. | 4·8 |
| | | | | | | 29)207·3 |
| | | | | | | Mean 7·2 |

* St. Bartholomew's Hospital Reports, Vol. XX.

## Appendix II.—*continued.*

It is evident from these results that days of fog should be avoided in testing the ventilation of a building by the carbonic acid method. Even if the carbonic acid in the outside air is determined at nearly the same as that inside the building, there remains some uncertainty, as during a fog the proportion outside may change very rapidly. Reiset showed that even in the country the carbonic acid may rise to 3·5 volumes during fog.

In almost any large manufacturing town the proportion of carbonic acid will probably rise during fog nearly as high as in London, though data on this point are still very scanty.

### Impurities in the Air of Factories and Workshops.

The impurities passing into the air of factories and workshops can best be classified according to their source. They arise (1) from persons present; (2) from lights burning; (3) from the floor, &c., of the room; (4) from manufacturing processes; (5) from accidental sources, such as escapes of gas, effluvia from drains, or impurities in the outside air.

#### 1.—*Impurities from persons present.*

The persons present in a room vitiate the air in several ways.

In the first place they give off carbonic acid, and at the same time consume oxygen in slightly (about a tenth) greater proportion. The amount of carbonic acid given off, and of oxygen consumed by a man varies considerably according to the amount of work being done. Thus, during great muscular exertion the amount may, for the time, be ten times as much as during rest. The average for the 24 hours can best be calculated from the average daily consumption of food, which is pretty accurately known, and corresponds to the production of about 22 cubic feet of carbonic acid, or 0·9 cubic foot per hour. During complete rest only about about 0·6 cubic foot per hour is given off, however. Hence during the hours of activity about 1·1 cubic feet per hour are produced. A woman produces a fifth less than a man. In a factory about 1 cubic foot per hour may therefore be taken as a probable average quantity per person, though a higher estimate would be needed in cases where there is much muscular exertion. It follows that, assuming the air of a workroom to be completely mixed, and allowing for the carbonic acid present (say 4·0 volumes per 10,000) in the air of a town, it would be necessary to supply more than 1,250 cubic feet of air per hour to each person in order to produce an atmosphere containing less than the 12 volumes of carbonic acid per 10,000 proposed in the preceding report.

Mere increase of carbonic acid and diminution of oxygen to the extent which actually occurs in the air of buildings has no direct influence on the comfort or health of the persons present. The proportion of carbonic acid, even where ventilation is very bad, seldom rises beyond 50 volumes per 10,000; and it requires about six times as much to produce an immediately perceptible effect (increased depth and frequency of breathing). A similar remark applies to the oxygen percentage. Neither a diminution nor an increase of 2 or 3 per cent. in the oxygen seems to produce any appreciable effect on a man. The living organism regulates its own consumption of oxygen, and in this respect differs entirely from a burning candle or fire, in the case of which the rate of consumption of oxygen rises and falls with the oxygen percentage in the air. A large fall in the oxygen percentage, or a corresponding diminution in the barometic pressure, produces the train of symptoms known to mountaineers as "mountain sickness"; but the diminution requires to be a very considerable one. Some of the best known health resorts are at altitudes where the diminution of pressure corresponds physiologically to a diminution by fully a fifth in the oxygen percentage. Further evidence showing that a moderate increase in carbonic acid and diminution of oxygen in the air is not in itself prejudicial to health is afforded by the fact that, apart from accidents, the life of a coal-miner is exceptionally healthy, although he breathes, when at work, air which contains a notable excess of carbonic acid and deficiency of oxygen owing to chemical changes in the coal. The importance of the carbonic acid in the air of a building arises solely from the fact that it is an index of conditions which are usually prejudicial to both health and comfort.

## Appendix II.—*continued.*

It was for long believed that along with the carbonic acid in expired air an organic substance, which is poisonous when absorbed into the blood, is given off from the lungs. Careful experiments have not corroborated this theory.* There is no doubt, however, of the unpleasant effects produced in the majority of persons by the air of badly ventilated rooms, and of the loss of health and increased liability to certain diseases, particularly consumption, associated with living in such air. There is also strong evidence of the influence of fresh air in both facilitating the cure and preventing the return of consumption and other diseases.

The increased liability to disease in persons living in badly ventilated rooms is in part attributable to the communication, through the air, of infective diseases ; and it is evident that the greater the air supply the less will be the chance of such communication occurring if any source of infection is present. Organisms present in the mouth and air-passages probably constitute the chief source of infection. During ordinary quiet breathing none of these appear to be given off in the breath, † but it has recently been shown that in speaking, and particularly in coughing and sneezing, large numbers are driven into the air and carried all over a room. ‡ Animals exposed to air contaminated by the coughing of consumptive patients have also been shown to become infected with tuberculosis. § Another mode of probable infection is from sputum which has been allowed to dry on the floor, so that the infective organisms are readily carried into the air as dust.

The loss of appetite, discomfort, headache, etc., produced by bad ventilation, cannot, however, have anything to do with infective organisms, which act far too slowly ; nor can the absence of such organisms explain the curative effects of fresh air on such diseases as consumption. It is evident, therefore, that other factors besides the presence of infective organisms must play an important part in connection with the ill effects of exposure to vitiated air, though the precise nature of these factors is still somewhat obscure.

The heat of an over-crowded room evidently aggravates the unpleasant effects, but they may still be produced, though not so readily, when excessive heat is absent ; and warm air by itself, particularly if it is in motion, does not produce the same effects. It is probable that the mere smell of the air of a badly ventilated room is one cause of the effects in question. This oppressive smell is usually very distinctly perceptible when the proportion of carbonic acid exceeds about 10 volumes per 10,000, or 6 to 7 volumes above that in outside air, and according to De Chaumont becomes imperceptible at about 2 volumes above outside air.¶ It appears to arise partly from the breath, but largely from the clothes and persons of those present in the room, and is caused by volatile substances present in the air in such minute amount that, though easily perceptible to our senses, they cannot be detected by chemical analysis. The importance of personal cleanliness, with a view to minimising the vitiation of air, is thus evident.

Expired air rises at first, since it is warmed. When it cools and mixes with pure air, the mixture has about the same specific gravity as pure air. The carbonic acid which replaces part of its oxygen tends to make it heavier, but this influence is neutralised by the increased proportion of aqueous vapour, the latter being lighter than air. Undiluted expired air contains, as compared with ordinary air, an excess of about 3·5 per cent. of carbonic acid and 5 per cent. of aqueous vapour, with a deficiency of about 4 per cent. of oxygen. The impurities arising from the persons present in a room pass upwards at first, but soon become pretty evenly distributed in the air at different levels owing to the influence of convection currents caused by the

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* Haldane and Lorrain Smith, Journal of Pathology and Bacteriology, Vol. 1, pp. 168,318 ; also Billings Weir Mitchell and Bergey, "The Composition of Expired Air, and its Effects upon Animal Life," Washington, 1895.

† Gunning, Centralbl. f.d. med. Wissenschaften, 1882 ; Carnelley, Haldane, and Anderson, Philos. Trans. 1887, B. p. 92.

‡ Flügge and Laschtschenko, Zeitschr. für Hygiene, Vol. 30, p. 126, 1899.

§ Flügge and Heymann, Zeitschr. für Hygiene, Vol. 30, p. 139, 1899.

¶ De Chaumont, Proc. Royal Society, Vol. 23, p. 187. De Chaumont's conclusions were based on an examination of the air of barracks. In rooms where the standard of personal cleanliness among the inmates is higher, the excess may in our experience considerably exceed two volumes without any unpleasant smell being perceptible. In factories and workshops the smell of the materials used may mask to a considerable extent the smell due to the persons present, so that it becomes difficult to judge of the purity of the air by the smell alone.

## Appendix II.—*continued.*

warmth of the body. This fact is illustrated by the following experiment on a room of 3,070 cubic feet capacity, and 11 feet high. Three women and one man were present in the room. The day was bright and sunny and there was no wind; the house was in the country: all openings were closed.

| | Volumes of $CO_2$. per 10,000 of air. |
|---|---|
| Before experiment. | 2·8 |
| After 20 minutes of occupation, at 4 ft. from floor | 5·5 |
| „ „ at roof | 4·7 |
| After 70 minutes at 4 ft. from floor | 10·9 |
| „ „ at roof | 11·5 |
| After 90 minutes at 4 ft. from floor | 12·8 |
| „ „ at roof | 12·1 |
| After 110 minutes at 4 ft. from floor | 15·0 |
| „ „ at roof | 15·0 |
| After 125 minutes at 4 ft. from floor | 15·3 |
| „ „ at roof | 15·2 |

### 2.—*Impurities from Lights.*

An ordinary gas-jet, such as is commonly met with at present in English factories and workshops, consumes from 5 to 10 cubic feet of gas per hour; and this amount of average English gas produces in burning about 2½ to 5 feet of carbonic acid, along with 5 to 10 feet of aqueous vapour, and consumes about 5 to 10 feet of oxygen. The mean of two analyses by one of us of ordinary 16 to 17 candle power gas, gave the following results per volume of gas burnt:—

| | | |
|---|---|---|
| Carbonic acid formed | 0·54 | volumes. |
| Aqueous vapour formed | 1·19 | „ |
| Oxygen consumed | 1·14 | „ |

As the aqueous vapour does not under ordinary conditions condense, the products of combustion are (apart from heating) lighter than ordinary air, for, although the carbonic acid is about 37 per cent. heavier than the oxygen which it replaces, the aqueous vapour is about 42 per cent. lighter, and present in much greater quantity. The mistake is often made of regarding air vitiated by the products of combustion as heavier than pure air. Roughly speaking, an ordinary gas jet produces as much carbonic acid as three men, and as much heat as five men. The combustion is quite perfect, and no carbonic oxide is given off, unless from any cause the flame is smoky, or is rapidly cooled by something in contact with it.

Were there no other products of combustion but carbonic acid and moisture, the changes produced in the air of rooms by the burning of gas would be of little practical importance apart from the rise of temperature. Lighting gas, however, contains not merely carbon and hydrogen, but also a little sulphur, chiefly in the form of carbon disulphide. This sulphur is burnt chiefly to sulphuric acid, which is the cause of the characteristic unpleasantness of air which is much vitiated by gas. The quantity of sulphur present in gas varies considerably in different towns, according as the gas is or is not thoroughly purified. In London, where the purification is good, and there is a legal limit to the amount of sulphur permitted in the gas, about 12 grains of sulphur per 100 cubic feet of gas are usually present; but in some of even the larger English towns, the amount of sulphur present may be much higher, so that the air becomes correspondingly more unpleasant when vitiated by burning gas. Air vitiated by gas-jets to the extent of 20 volumes of carbonic acid per 10,000 begins to feel distinctly oppressive even with well-purified gas. In air vitiated to the extent of even as much as 75 volumes of carbonic acid by a good and clean paraffin lamp we could observe no similar effect.

The relative increase of air-vitiation in any given workroom after the gas is lit will evidently vary with the proportion of gas-jets to persons present. This proportion differs very greatly in different workrooms. Where there is much machinery or floor-space to each worker the number of gas-jets may greatly exceed the number of workers. Thus in spinning-rooms (Appendix I., Table O) there are often three or four jets to each person; consequently the production of carbonic acid after gas is lit may rise to ten or twelve times what it was during daylight. On the other hand in the more crowded rooms where sewing, etc., are carried on there may be only

## Appendix II.—*continued.*

about one jet to two or three persons (Tables A to D) so that the production of carbonic acid is only about doubled after gas is lit.

In view of these facts the effects of burning gas on the state of the air in any room ought always to be considered in connection with the means of ventilation. When the heated air from gas-jets has prompt means of escape above, the actual vitiation of air at the breathing level may not be much increased. But when the air at all levels is allowed to mix before escaping, or is kept in mixture by belts from shafting in the roof or other causes, the effect of burning gas on the purity of the air is often very great. This is shown very distinctly in the analyses of air from weaving sheds (Appendix I., Table N, and particularly Table P.)

A good deal may often be done towards diminishing the vitiation of the air by avoiding wasteful methods of consuming gas. The following table shows the results of a series of experiments by one of us on the light obtained for a given consumption of gas with various forms of ordinary burner in common use. The experiments were made with London gas, averaging at the time about 16·5 candle power, *i.e.*, giving a light of 16·5 standard candles when burnt at a rate of 5 cubic feet per hour through the standard "London Argand" burner. The standard light used in the experiments was the official 10-candle pentane lamp of the Metropolitan Gas Referees. The results with mantles are from a report published by the German Association of Gas and Water Engineers. ("Journal of Gas Lighting," April 16, 1901.)

| Description of Burner. | Pressure in inches of water between tap and burner. | Consumption of gas in cubic ft. per hour. | Light in candles. | Light in candles per cubic ft. of gas burned. |
|---|---|---|---|---|
| Standard "London Argand." | — | 4·86 | 16·0 | 3·29 |
| "Union" or "Fishtail" No. 8. | 1·7 (*) | 12·6 | 22·6 | 1·79 |
| | 1·4 | 11·2 | 24·0 | 2·14 |
| | 0·8 | 8·2 | 23·7 | 2·87 |
| | 0·4 | 5·6 | 17·5 | 3·12 |
| | 0·2 (**) | 3·15 | 9·1 | 2·89 |
| "Union" No 6. | 1·8 (*) | 10·0 | 12·8 | 1·28 |
| | 1·2 | 8·1 | 15·7 | 1·94 |
| | 0·8 | 6·25 | 14·3 | 2·29 |
| | 0·4 | 4·15 | 10·0 | 2·41 |
| "Union" No. 4. | 2·0 | 9·4 | 6·1 | 0·65 |
| | 1·7 | 8·3 | 8·9 | 1·07 |
| | 1·2 | 6·7 | 9·4 | 1·40 |
| | 0·8 | 5·1 | 8·4 | 1·65 |
| | 0·4 | 3·6 | 6·8 | 1·89 |
| "Union" No. 2. | 1·8 | 5·5 | 3·45 | 0·63 |
| | 1·2 | 4·5 | 3·45 | 0·77 |
| | 0·8 | 3·8 | 3·5 | 0·92 |
| | 0·4 | 2·4 | 2·8 | 1·17 |
| | 0·2 (**) | 1·45 | 1·9 | 1·34 |
| "Union" No. 0. | 1·9 | 4·5 | 1·6 | 0·36 |
| | 1·2 | 3·5 | 1·7 | 0·49 |
| | 0·8 | 2·7 | 1·6 | 0·59 |
| | 0·4 | 1·55 | 1·3 | 0·84 |
| | 0·2 (**) | 0·97 | 0·88 | 0·91 |
| "Batswing economiser" No. 7, placed on Union No. 0. | 1·0 | 4·5 | 14·7 | 3·27 |
| | 1·2 | 3·5 | 11·0 | 2·97 |
| | 0·2 (**) | 0·97 | 2·1 | 2·16 |
| "Union economiser" No. 6, placed on Union No. 2. | 2·3 | 5·9 | 13·9 | 2·36 |
| | 1·8 | 5·25 | 12·4 | 2·36 |

*Flaring. **Small flame.

## Appendix II.—*continued.*

| Description of Burner. | Pressure in inches of water between tap and burner. | Consumption of gas in cubic ft. per hour. | Light in candles. | Light in candles per cubic ft. of gas burned. |
|---|---|---|---|---|
| Common iron batswing, no number (Irregular flame). | 0·6 (*) | 16·0 | 37·3 | 2·33 |
| | 0·4 | 13·0 | 37·7 | 2·90 |
| | 0·3 | 10·0 | 34·2 | 3·26 |
| | 0·2 | 7·6 | 25·3 | 3·33 |
| | 0·15 | 5·5 | 17·8 | 3·24 |
| Batswing No. 7. | 1·1 | 12·0 | 26·2 | 2·18 |
| | 0·7 | 9·5 | 22·9 | 2·41 |
| | 0·4 | 6·1 | 18·2 | 2·98 |
| Cone-top burner, no number. | 1·8 | 6·8 | 21·6 | 3·18 |
| | 1·2 | 4·55 | 14·5 | 3·19 |
| | 0·5 (**) | 1·8 | 4·55 | 2·53 |
| Cone-top governor burner. | 2·0 | 4·95 | 16·05 | 3·24 |
| | 1·0 | 4·8 | 15·65 | 3·26 |

*Flaring. **Small flame.

| | Pressure in inches of water between tap and burner. | Consumption of gas in cubic feet per hour. | Light in candles. | Light in candles per cubic ft. of gas burned. |
|---|---|---|---|---|
| Average of incandescent mantles. | | | | |
| After 1 hour's use. | — | 4·25 | 73·9 | 17·4 |
| „ 24 „ „ | — | 4·25 | 70·3 | 16·5 |
| „ 100 „ „ | — | 4·25 | 62·2 | 14·6 |
| „ 300 „ „ | — | 4·25 | 56·4 | 13·3 |
| „ 600 „ „ | — | 4·25 | 53·8 | 12·7 |

It will be seen from this table how greatly the amount of light obtained per cubic foot of gas burnt varies according to the method of consumption. The light is 48 times as great with the best as with the worst method. With ordinary burners the best result is evidently obtained from those with the larger sizes of opening, and with the gas issuing gently. Thus, to take an extreme instance, the light from a No. 0 burner at full pressure was increased nine times when a No. 7 burner (so-called "economiser") was slipped over it. When, as is very commonly the case in factories, the gas is allowed to issue at the full available pressure, it burns very wastefully, and in spite of the greatly increased consumption the light obtained is often less, while the light per cubic foot of gas burnt is very greatly less. The best result with a given burner is obtained when the gas is allowed to issue as gently as is consistent with a sufficiently steady flame. This can be insured by placing a pressure-governor on the main supply, or using governed burners, provided the pressure in the mains is sufficient.

The table shows clearly the great economy in gas consumption when mantles are used. Their much more general employment in factories and workshops is very desirable with a view to avoiding excessive vitiation of the air, and at the same time obtaining a good and perfectly steady light.

By the use of the incandescent electric light all the inconvenience due to air vitiation and heat from gas-jets can be avoided, though the extra expense as compared with incandescent gaslight is considerable. The arc electric light, so shaded that only reflected light falls on the employees and machines, is in some cases very advantageous.

The most wasteful methods of burning gas are still very commonly used in factories and workshops, in spite of the greater expense and increased vitiation of air. Much improvement could certainly be effected by increased attention on the part of employers to improved methods of lighting. The most suitable methods will vary according

## Appendix II.—*continued.*

to a number of circumstances, and skilled advice on the subject should be obtained when necessary.

The heated air containing the products of combustion of a gas-jet passes straight up to the roof in a concentrated stream. It there parts with most of its heat, and unless it is permitted to escape is slowly displaced downwards again, to be again partially carried up by the flame. As, however, gas-jets are usually placed at six feet or more from the floor this circulation of hot and vitiated air is to a large extent above the breathing level, so that the air actually breathed is not so much vitiated as would otherwise be the case. The following analyses of the air in a room of 5,700 cubic feet and 11½ feet high illustrate this point. All openings were closed, and only one person was present. Three No. 4 Union burners were lit, passing in all about 15 cubic feet of gas per hour. The gas-jets were at a height of 6½ feet from the floor, on the walls at opposite sides of the room. The samples were taken at the centre of the room. The temperature outside was about 9 deg. C.

| | Volumes of $CO_2$ per 10,000. | | | Temperature C. | |
|---|---|---|---|---|---|
| | at 1 ft. fr. floor. | at 4 ft. fr. floor. | at 1 ft. fr. roof. | at 4 ft. fr. floor. | at 1 ft. fr. roof. |
| Before gas lit. | | 2·9 | | 12·5° | 12·5 |
| 13 min. aft. gas lit. | | | 13·8 | | |
| 18 „ „ „ „ | | 4·8 | | | |
| 24 „ „ „ „ | 7·5 | | | | |
| 30 „ „ „ „ | | | 20·2 | | |
| 36 „ „ „ „ | | 9·0 | | | |
| 44 „ „ „ „ | 12·7 | | | | |
| 53 „ „ „ „ | | 13·9 | | | |
| 59 „ „ „ „ | | | 27·7 | | |
| 64 „ „ „ „ | 16·5 | | | | |
| 68 „ „ „ „ | | 17·4 | | | |
| 90 „ „ „ „ | | | 34·3 | | |
| 96 „ „ „ „ | | 19·4 | | | |
| 102 „ „ „ „ | 19·6 | | | 15° | 18·8° |
| 140 „ „ „ „ | | | 39·0 | | |
| 144 „ „ „ „ | | 25·8 | | | |
| 148 „ „ „ „ | 24·8 | | — | 15·4° | 19·4° |

In calculating the probable effect of combustion of gas on the purity of the air of a room it is evidently necessary to consider to what extent the arrangements for ventilation permit the heated air from gas-jets to escape without vitiating the air at the breathing level. In high rooms the air at the breathing level will be less vitiated than in low rooms. In rooms such as weaving-sheds, where the driving belts for machinery are constantly mixing the air at different levels, or where the incoming air is introduced at a high level, there will naturally be more complete mixture than in other rooms, so that more fresh air will be needed to keep the air at the breathing level reasonably pure. In the weaving shed, Table P, Appendix I., with 2⅓ gas-jets per person, the excess of carbonic acid rose from 3 to 12 when the gas was lit.

When two or more floors are in free communication by stairs, lifts, or other communications, the effects on the upper rooms of gas burning in the rooms below must also be taken into consideration, as the vitiated air will all pass upwards, as is shown by a number of the analyses in Appendix I. When the building is warmer than the outside air the vitiated air will ascend, whether it be produced by gas or by respiration. Thus in Nos. 7 to 10, Table I (Printing), the air in the top floor contained an excess of 21 volumes of carbonic acid, but in the basement of only 6·6 volumes, while the air entering the top floor by the shaft of the lift contained 13 volumes in excess. Hardly any gas was burning. In Nos. 15 and 16 of the same table the excess in the air entering by the stairs was 10·3 volumes, and in the room itself 15·3 volumes. In Nos. 17 to 19 the excess in the first door was 3·3; in the second floor 5·8; and in an empty upper floor, with no persons or gas-jets, 7·5. In Nos. 1 to 3, Table K, the excess was 12 in the room itself, and 9·3 in the air coming up through a grid below. Other similar instances will be noticed in Table A and elsewhere; and it will also be seen that in basement rooms the air was usually found to be relatively pure. Frequently the basement and ground floor rooms act as intakes for the whole building.

## Appendix II.—*continued.*

### 3.—*Ordinary Dust from Floors, etc.*

The air of all factories and workshops, whether or not the process is a dusty one, is necessarily contaminated to some extent with light dust from the floors, etc., the amount depending on the cleanliness of the room. This dust originates partly from the clothes and persons of those who are or have been present in the room and is thus liable to contain infective micro-organisms. Some idea of the manner in which such organic dust accumulates in a room may be formed from determinations of the number of bacteria of all kinds present in the air, and the following average results may be quoted here in illustration.*. The outside air (winter) contained an average of 0·8 micro-organisms per litre.

| | | Micro-organisms per litre of air. | | | Micro-organisms per litre of air. |
|---|---|---|---|---|---|
| Elementary schools in Dundee with natural ventilation | Cleaner | 91 | One-roomed dwellings in Dundee | Cleaner | 18 |
| | Average | 125 | | Average | 45 |
| | Dirtier | 198 | | Dirtier | 93 |
| Elementary schools in Dundee with natural ventilation | Opened over 20 years | 311 | Two-roomed dwellings in Dundee | Cleaner | 10 |
| | Opened 2 to 20 years | 150 | | Average | 22 |
| | Opened less than 2 years | 38 | | Dirtier | 69 |

A number of determinations of bacteria in work-rooms were made by the Committee (*see* Appendix I). It soon, however, became evident that the results were so much influenced by the nature of the dust peculiar to the work that they were of limited value. Very little significance can be attached to the presence of even large numbers of bacteria in the air if these bacteria are derived from material which is not likely to contain germs of disease. Thus the largest number of bacteria found (805 per litre) in the samples of air examined was in a rope factory, and there seemed no reason to suspect that these bacteria, which evidently came from the hemp, contained among them any that were not perfectly harmless. On the whole, the 39 analyses made (chiefly among printers', book-binders', tailors', and milliners' workrooms) indicated a satisfactory standard of cleanliness in most of the rooms examined. The average number found (excluding the rope factory results) was 8·0 bacteria and 2·2 moulds, or 10·2 micro-organisms per litre of air. This may be compared with the averages of 152 for elementary schools in Dundee, 76 for country board schools in Scotland, 60 for one-roomed dwellings, 46 for two-roomed dwellings, 9 for the better classes of dwellings, and 0·8 for outside air in Dundee in winter†.

The figures given above show the close connection which exists between general cleanliness of a room and the purity of the air. Of particular importance in this reference is the prevention of expectoration on the floors, on account specially of the readiness with which infected persons may probably communicate phthisis by this means. Many employers have already taken special measures to prevent expectoration on the floors of their workshops; and it is to be hoped that this example will soon be universally followed.

### 4.—*Dust and Fumes from Manufacturing Processes.*

As we hope to refer to dust and fumes in a further report, only a few remarks on the subject are needed here. Wherever possible, dust, fumes, and evil-smelling vapours should be dealt with at their point of origin, and never allowed to mix with the general atmosphere of a room. Where this is not done the only remedy is to increase the general ventilation to such an extent as to sufficiently dilute the impurities. The result of such a course is, however, apt to be very unsatisfactory, as sufficient ventilation often cannot be obtained without exposing the workers to an intolerable amount of cold and draught, or incurring great expense in warming the incoming air. Moreover the increased ventilation often carries through a room a great deal of dust which would otherwise subside in the immediate neighbourhood of the machine which produces it.

* Carnelley, Haldane, and Anderson, Philos Transact., 1887, B., p. 61.

† Carnelley, Haldane, and Anderson, Philos. Transactions, 1887, B., p. 79; also Carnelley and Foggie, Journal of Pathology and Bacteriology, Vol II., p. 157.

## Appendix II.—*continued.*

### 5.—*Accidental Impurities.*

The air of a workroom may be contaminated from sources outside the room, as from leaky drains, or badly kept urinals or water closets. The smells thus arising may, like other unpleasant smells, affect the general health of those exposed to them, although it is not at all probable that specific diseases are communicated by so-called "sewer gas."* A badly designed, badly lit, or badly kept urinal or water closet may easily be the means of communicating infective diseases, particularly as it is now known that the excreta of persons who have recovered from infectious diseases, or merely been in contact with others suffering from them, may be infective. It is evident that impurities communicated to the air of workrooms from the above-mentioned sources can best be dealt with at their origin.

Another accidental impurity which is occasionally of importance is ordinary lighting gas, or gas used for driving engines. Ordinary lighting gas contains about 7 per cent. of carbonic oxide. Carburetted water-gas, which is often mixed with the ordinary gas, contains about 30 per cent. of carbonic oxide, Dowson and producer gas also contain about 30 per cent., while pure water-gas contains nearly 50 per cent. As anything more than about ·03 per cent. of carbonic oxide will produce headache etc., after several hours' exposure, and as little as ·2 per cent. carbonic oxide is dangerous to life, it is evident that, even apart from the risks of explosion or fire, escapes of gas should not be permitted in factories and workshops. Very special care is needed with pure water-gas, producer-gas, Dowson gas, etc., as they have only a slight smell. It occasionally happens also that coal-gas, when it escapes from a broken pipe underground, is to a large extent deodorised in passing through the ground, so that the smell is only slight when it is present in dangerous amount. Carbonic oxide is also produced in large quantities in place of carbonic acid whenever the combustion of gas is imperfect, as when a non-luminous flame used for heating purposes is allowed to "strike back." When this is the case the products of combustion have a peculiar unpleasant smell which can at once be recognised. Some forms of the gas-heated irons used in tailoring workshops, etc., are very liable to this defect, so that they require careful supervision.

When an accidental escape of lighting gas occurs above the breathing level it may happen that the gas passes up so completely towards the roof that the escape is not noticed at first, and if from any cause the upper stratum of air becomes afterwards mixed with the stratum at the breathing level the effects on persons present may be serious. Accidents of this kind have occasionally been observed in weaving sheds. The gas has been turned off at the meter on stopping work for breakfast, but through some mistake the tap has been turned too far, so that gas is left escaping all over the shed. On starting the machinery again after breakfast the action of the driving belts has mixed the upper with the lower strata of air, the result being that in a short time many of the operatives have experienced symptoms of poisoning.

An accidental impurity which often causes serious inconvenience in manufacturing processes, and indirectly leads to the air supply being restricted to an undesirable extent, is soot and dust from the outside. Where the outside air contains much soot and dust, a room, particularly if well ventilated, is apt to serve to some extent as a settling chamber for the particles carried in by the relatively rapid currents of incoming air. With work in white materials particularly, much trouble may be thus caused. In such cases it is desirable to filter the incoming air, which ought, as a rule, to be forced in by a fan, the arrangements being such that all openings except the air-inlet act as outlets. The filtration may be effected by means of an open-meshed cloth placed diagonally along an inlet shaft so as to cause a minimum of obstruction, and occasionally removed for cleaning when it becomes choked; or a continuously acting water screen may be employed. Either of these arrangements will remove the grosser soot and dust particles, but not the finer ones. To remove the finer particles the air must be filtered through some such materials as cotton wool or slag wool. Underneath the House of Commons a cotton wool filter is employed to filter off the fine smoke particles which abound in the air of London on days of fog. This filter is placed in the inlet air-passage, and so arranged as to present a very large filtering surface

* Sewer air is nearly free from bacteria, and those bacteria which are present come almost entirely from the outside, through ventilators, etc. (Carnelley and Haldane, Proc. Royal Society, Vol. 42, p. 501, 1887; Petri, Zeitschr. f. Hygiene, vol. 3, 1888, p. 127; Laws, Report to the London County Council on Sewer Air, 1893.,

Appendix II.—*continued.*

(1,000 square feet). The cotton wool is six inches thick, and is held in position by wire netting on a wooden frame. It was found by one of us to pass 1,500,000 cubic feet of air per hour, or 1,500 cubic feet per hour per square foot of surface, with a difference of pressure between the two sides of 4·2 m.m. (0·17 inch) of water, or 1·0 lb. per square foot. The pressure was produced by an ordinary propeller fan working at a rather high velocity. Laboratory experiments showed, further, that the flow of air through cotton wool, porous earth, and other similar materials varies directly as the pressure, and thus follows a quite different law from the flow of air through a constricted opening. (*See* below.) A cotton wool filter is apt to become blocked pretty rapidly during fog unless the air is warmed somewhat so as to keep the filter dry.

### Influence of Impurities on the Composition of the Air.

It is evident that if no fresh air at all entered a room containing persons, and perhaps also burning lights, the air would very soon become exceedingly foul. The air of a perfectly air-tight room containing one person at work to every 250 cubic feet of air space would, for instance, at the end of an hour contain about 40 volumes of carbonic acid per 10,000 of air, and would smell very unpleasant. At the end of eight hours the air would be so foul that candles or lamps would no longer burn on account of the diminished oxygen percentage* : everything would be damp from condensed moisture; and more or less noticeable panting would be produced in the persons present by the accumulation of carbonic acid. Probably also most of those present would suffer from nausea and headache. If there were one ordinary gaslight to every three or four persons these effects would be produced in about half the time. Such a state of matters is, however, never observed in ordinary rooms. There are always means of some kind by which the air is constantly being changed, whether or not the ventilation is what would be regarded as adequate. On the amount of ventilation relatively to the rate at which the air is vitiated by the persons and lights present depends in the long run the degree of vitiation of the air.

Supposing the air of the room to be pure at first, a certain interval will elapse before the impurity of the air reaches an amount beyond which it does not further increase. The larger the air space per person or per light in the room and the less adequate the means of ventilation, the longer will be this interval. Thus let us suppose the common case that with no gas lit, the carbonic acid ceases to increase at nine volumes per 10,000 (the legal maximum in Humidified Cotton Cloth Factories) or five volumes above what is present in the outside air of a large town in winter. On the assumption that the air is completely mixed and that each person produces about one cubic foot of carbonic acid per hour (*see* above) it follows that 2,000 cubic feet of air per person are entering the room. Hence, if there are 250 cubic feet of air space per person the air of the room is on an average changed about once in $7\frac{1}{2}$ minutes. With 1,000 cubic feet per person it is changed once in half an hour. In the first case the carbonic acid present as impurity will have reached nearly (within about a seventh from) its maximum after 15 miuutes; in the second case after an hour.

With the common enough provision of one gas-jet burning about 8 cubic feet per hour (and producing 4 cubic feet of carbonic acid) for every 1,000 cubic feet of air space the carbonic acid would, with the same persons present, the same air-supply and complete mixture of the air, finally reach 14 volumes per 10,000 in the first case and 29 volumes in the second case.

It will thus be seen that unless where the cubic space per person is very large or the ventilation very bad, the degree of impurity in the air. will, after a comparatively short interval from the time of commencement of work, depend not on the air space per person in the room, but on the volume of fresh air introduced per person and per cubic foot of gas burnt.

In the following table we have arranged the observations in Appendix I. so as to show the relations between the air space per person and the proportion of carbonic acid in the air. Where several analyses have been made of the air in one room the average for daylight or gaslight in that room has alone been counted in constructing the table, so that the general average may be as fair as possible.

* A candle is extinguished when the oxygen percentage falls below 17·5.

Appendix II.—*continued.*

| Cubic feet per person. | | Under 300. | 300 to 400. | 400 to 600. | 600 to 1,000. | 1,000 to 1,500. | 1,500 to 2,000. | 2,000 to 5,000. | Over 5,000. |
|---|---|---|---|---|---|---|---|---|---|
| Average cubic ft. per person - | | 233 | 339 | 496 | 760 | 1,227 | 1,689 | 2,906 | 9,404 |
| Volumes of $CO_2$ per 10,000 | Daylight or Electric light | 11·4 | 10·6 | 9·7 | 10·2 | 9·2 | 9·0 | 7·1 | 12·8 |
| | Gas-light or lamp-light | 20·1 | 13·6 | 14·0 | 13·8 | 17·4 | 19·0 | 17·8 | 26·3 |
| Number of rooms examined | Daylight or Electric light | 36 | 33 | 28 | 27 | 27 | 25 | 24 | 25 |
| | Gas-light or lamp-light | 14 | 8 | 15 | 18 | 14 | 9 | 5 | 12 |

It will be seen from the table that there is no general decrease in the carbonic acid with increase in the cubic space per person; and indeed the highest results were obtained, curiously enough, in the rooms with most space per person. This was evidently due partly to the fact that a large number of these rooms were spinning-rooms, which are commonly kept tightly closed in order to prevent cooling or injury to the product from external atmospheric changes. In gas-lit rooms there is on the whole a marked relative increase in carbonic acid in rooms with a large cubic space per person. This is explained by the fact that in such rooms the proportion of gas-jets to persons is usually much greater than in rooms with a small cubic space per person. It is quite clear from the table that a large cubic space per person affords no guarantee for purity of the air. In factories and workshops, where rooms are always continuously occupied for some hours, foul air is about as often met with in sparsely occupied as in crowded rooms.

In testing the ventilation of a room by analysis of the air, it is important to know how far the result is affected by the time during which the room has been in continuous occupation. The following table, for which we are indebted to Mr. P. J. Kirkby, Fellow of New College, Oxford, furnishes an easy means of calculating the probable maximum to which the proportion of carbonic acid in the air of a room will ultimately rise, and the rate of ventilation, assuming the latter to remain constant, and the mixture of the air to be fairly complete.

| $\frac{E}{E_o}$ | $\frac{T}{t}$ | $\frac{E}{E_o}$ | $\frac{T}{t}$ | $\frac{E}{E_o}$ | $\frac{T}{t}$ |
|---|---|---|---|---|---|
| ·95 | 10· | ·72 | 1·43 | ·50 | ·62 |
| ·93 | 7·5 | ·69 | 1·25 | ·48 | ·59 |
| ·90 | 5· | ·66 | 1·1 | ·45 | ·53 |
| ·87 | 3·3 | ·63 | 1·0 | ·43 | ·50 |
| ·85 | 3·0 | ·61 | ·91 | ·40 | ·45 |
| ·82 | 2·5 | ·58 | ·83 | ·37 | ·40 |
| ·79 | 2·0 | ·56 | ·77 | ·35 | ·37 |
| ·77 | 1·8 | ·54 | ·71 | ·30 | ·31 |
| ·75 | 1·67 | ·52 | ·67 | ·25 | ·25 |

To use the table it is first necessary to calculate the excess of volumes of carbonic acid per 10,000 of air, which would have been present with no ventilation at all. As each person produces about a cubic foot of carbonic acid per hour, this number ($E_o$) is found by multiplying the persons present by the time in hours of occupation, and dividing the result by the cubic feet of air space in the room divided by 10,000. Thus if the room has a capacity of 50,000 cubic feet, and 150 persons have been present for half an hour, $E_o$ will be $= \frac{150 \times 0{\cdot}5}{\frac{50{,}000}{10{,}000}} = 15$. The ratio of the observed excess (E) to $E_o$ is then calculated. Thus if 10 volumes have been found in the air E may be taken as $10-4=6$, if the room is in a large town; and the ratio $\frac{E}{E_o}$ will be $\frac{6}{15} = 0{\cdot}4$. The maximum to which E will subsequently rise is then found by multiplying $E_o$ by the number standing opposite to the value of $\frac{E}{E_o}$ in the second column of the table. As

Appendix II.—*continued.*

in the supposed case this value is 0·4, and the number opposite is 0·45, the required maximum value of E is 15 × 0·45 = 6·7, so that the carbonic acid will ultimately rise to 6·7 + 4 = 10·7 volumes per 10,000.

If the ratio $\frac{E}{E_o}$ is less than the least number in the first column, the corresponding number in the second column is the same, as the two columns have reached an equality. In this case the maximum proportion of carbonic has been reached, and there will be no further vitiation. Practically speaking, if the ratio $\frac{E}{E_o}$ is less than a third the maximum has been reached: if the ratio is $\frac{1}{2}$, the maximum excess is a fourth greater than E. If the ratio $\frac{E}{E_o}$ is greater than unity it is pretty certain that the air of the room was not pure to start with (Table O, Nos. 41, 45, 58, 59, 60, 61, Appendix I.) or that gas, has been burning (Table O, No. 43.) or impure air entering the room.

The numbers in the second column of the table are in each case the ratio of the time (T) required for the air of the room to be completely changed to the time (t) during which the room has been occupied. It is thus easy to calculate the value of T; and the cubic capacity of the room divided by T gives the number of cubic feet of air per hour being introduced. Thus in the above sample, since $\frac{T}{t}$ was 0·45, and t was 0·5, T = 0·5 × 0·45 = 0·225, and the ventilation per hour was $\frac{50,000}{0·225}$ = 222,000 cubic feet, or $\frac{220,000}{150}$ = 1,480 cubic feet per person.

The application of the table is illustrated by the experiments with burning candles described below, and by a number of observations described in Appendix I. It must always be borne in mind that the temperature of a room frequently increases up to a certain point with the duration of the occupation, and that this may increase the rate of ventilation, so that the excess of carbonic acid will not actually rise so high as the calculated excess. The accuracy of the calculation is also limited by the fact that the production of carbonic acid per person may be somewhat greater or less than 1 cubic foot per hour, according to the nature of the work, etc.

For practical purposes the following abbreviated table will be found useful.

| When the value of $\frac{E_o}{E}$ - - - - - - - | 3 or more | 2 | 1·75 | 1·5 | 1·25 |
|---|---|---|---|---|---|
| The probable maximum future excess will be E × - - | 1 | 1·24 | 1·4 | 1·7 | 2·7 |

The probable number of cubic feet of fresh air per person and per hour is obtained by dividing 10,000 by the value obtained for the maximum future excess.

As the conditions in the rooms of different factories and workshops vary very greatly, and the most suitable and economical means for obtaining satisfactory ventilation vary correspondingly, so that any uniform system of ventilation for all is out of the question, we have thought it most useful to give in the following pages a general account of the different ways in which fresh air is, or may be, introduced, and of the conditions which modify the effects produced.

## Natural Ventilation Without Special Openings.

In all rooms a certain amount of exchange of air occurs through the walls, roof floor, and various chinks, as was originally proved by Pettenkofer. He showed experimentally that when all visible chinks were closed in a room investigated by him the rate of ventilation was only diminished by 28 per cent., as compared with the rate when the windows and door were only closed in the ordinary way. How free the passage of air may be is shown by the fact that even in a small room there is still a brisk draught up the chimney after the door and windows are tightly closed. Thus in a room of 1,400 cubic feet used for some of the experiments described below the chimney draught was 4,450 cubic feet per hour, so that this amount of air was entering through the walls, etc.

As it was important to obtain some general ideas as to the amount of air which may pass through a room unprovided with special openings for ventilation, a number of ex-

## Appendix II.—*continued.*

periments on this point were made by one of us. The method adopted was to leave the room closed with a certain number of paraffin candles burning at even intervals over the floor. From the weight of paraffin burnt in a given time the volume of carbonic acid produced (which was found by experiment to be ·058 cubic feet at 60 deg. F. and 29·9 inches barometic pressure per gramme of candle burnt) could be estimated, so that from the excess of carbonic acid in the room above that of the outside air the volume of air entering the room could easily be calculated from the table already given. It will be seen that the percentage of carbonic acid from the candles was in some experiments somewhat higher near the roof or on one side, but the calculations are based on the analyses of samples taken at the centre of the floor and at the breathing level. In the experiments on the first room * the ventilating effects of an open fireplace are also shown. In all cases the rooms and surrounding rooms were thoroughly ventilated before starting, and since the buildings were practically in the country the proportion of carbonic acid could safely be assumed to be as nearly as possible 3·0 volumes per 10,000 in the room before starting and in the outside air. Where not otherwise stated the samples were taken in the centre of the room at a height of about 4 feet from the floor. If any person was present during the experiment the carbonic acid produced by him was allowed for. The analyses were by the method described in Appendix III.

| Description of room. | Cubic ft. of $CO_2$ formed per hour. | Hours since candles lighted. | Temperature Centigrade. Ins. | Temperature Centigrade. Out. | Vols. of $CO_2$ per 10,000. | Hours required for a volume of air equal to that of the room to enter. | Remarks. |
|---|---|---|---|---|---|---|---|
| Room A. — Capacity 1,390 cubic ft., and 9·3 ft. high. Bedroom on first floor. Fireplace and one window. One outside wall of brick. Walls and ceiling papered. | 1·29 | 1·1 | | | 8·5 | 0·8 | Flap of fireplace open. Breeze scarcely perceptible throughout experiment. |
| | ,, | 1·1 | | | 10·9 | | At roof. |
| | ,, | 4·1 | 16° | 14·2° | 13·1 | 1·1 | |
| | ,, | 4·1 | | | 15·1 | | At roof. |
| | ,, | 5·6 | | | 12·6 | 1·0 | Chimney draught= 620 cubic ft. per hour. |
| | ,, | 5·6 | | | 15·7 | | At roof. |
| Same room - - - | 1·26 | 2·7 | 16·7° | 9·0° | 12·1 | 1·0 | Flap open. Very slight breeze. |
| | ,, | 2·7 | | | 17·5 | | At roof. |
| | ,, | 3·7 | | | 10·9 | 0·9 | Chimney draught= 700 cubic ft. per hour. |
| | ,, | 3·7 | | | 16·5 | | At roof. |
| Same room - - - | 1·40 | 3·1 | 17·2° | 16·7° | 21·8 | 2·7 | Flap closed. Breeze scarcely perceptible throughout experiment |
| | ,, | 3·1 | | | 22·7 | | At roof. |
| | ,, | 4·1 | | | 26·7 | 3·4 | |
| | ,, | 4·1 | | | 27·1 | | At roof. |
| | 1·36 | 5·1 | | | 26·7 | 2·9 | |
| | ,, | 5 1 | | | 27·2 | | At roof. |
| | ,, | 6·1 | | | 23·2 | 2·1 | |
| | ,, | 6·1 | 17·8° | 13·3° | 29·1 | | At roof. |
| | ,, | 9·6 | | | 24·6 | 2·2 | |
| | ,, | 9·6 | | | 30·1 | | At roof. |
| | ,, | 11·6 | 17·8° | 10·6° | 27·2 | 2·5 | |
| | ,, | 11·6 | | | 28·2 | | At roof. |
| Same room - - - | 1·31 | 2·0 | 17·9° | 14·5° | 14·5 | 1·8 | Flap closed, strong wind throughout experiment. |
| | 1·31 | 2·0 | | | 16·9 | | At roof. |
| | 1·41 | 3·0 | | | 15·3 | 1·5 | |

* These first experiments were made by one of us for Appendix I. of the Report of the Departmental Committee on the Use of Water-gas (Parliamentary Paper 1899).

## Appendix II.—*continued.*

| Description of room. | Cubic ft. of $CO_2$ formed per hour. | Hours since candles lighted. | Temperature Centigrade. Ins. | Out. | Vols. of $CO_2$ per 10,000. | Hours required for a volume of air equal to that of the room to enter. | Remarks. |
|---|---|---|---|---|---|---|---|
| Same room - - - | 1·41 | 3·0 | | | 19·1 | | At roof. |
| | ,, | 4·0 | 18·0° | 13·3° | 16·7 | 1·5 | |
| | ,, | 4·0 | | | 18·2 | | At roof. |
| | ,, | 6·0 | | | 17·2 | 1·4 | |
| | ,, | 6·0 | | | 17·2 | | At roof. |
| | ,, | 7·5 | | | 16·7 | 1·3 | |
| | ,, | 7·5 | | | 18·7 | | At roof. |
| | ,, | 8·5 | | | 16·7 | 1·3 | |
| | ,, | 8·5 | | | 18·7 | | At roof. Flap opened afterwards |
| | ,, | 11·0 | 18·3° | 11·0° | 9·9 | 0·7 | |
| | ,, | 11·0 | | | 9·0 | | At roof. |
| | ,, | 12·5 | | | 9·4 | 0·6 | Chimney draught = 2,700 cubic ft. per hour. |
| | ,, | 12·5 | | | 9·9 | | At roof. |
| Same room - - - | 1·35 | 2·0 | | | 11·2 | 0·9 | Flap closed. Moderate breeze. |
| | ,, | 2·0 | 18·3° | 15·8° | 17·9 | | At roof. |
| | ,, | 3·0 | | | 14·6 | 1·3 | |
| | ,, | 3·0 | | | 17·5 | | At roof. |
| | ,, | 5·5 | | | 22·6 | 2·2 | Breeze now very slight. |
| | ,, | 5·5 | | | 22·7 | | At roof. |
| | 1·37 | 6·5 | | | 19·7 | 1·7 | |
| | ,, | 11·5 | 18·5° | 10·7° | 26·7 | 2·4 | No breeze. Lower sash of window now raised 7 inches. |
| | ,, | 13·0 | | | 9·8 | 0·7 | |
| | ,, | 13·0 | | | 12·4 | | At roof. |
| | ,, | 14·0 | 17·4° | 10·2° | 10·8 | 0·8 | |
| | ,, | 14·0 | | | 14·1 | | At roof. |
| Same room - - - | 1·36 | 1·3 | 19·4° | 13·5° | 4·8 | 0·2 | Fire burning brighly in grate. Slight breeze. |
| | | | | | 4·8 | | Chimney draught = 4,450 cubic ft. per hour. |
| | ,, | 1·3 | | | 4·8 | | At roof. |
| | ,, | 2·0 | 19·4° | 13·5° | 6·5 | 0·4 | |
| | ,, | 2·0 | | | 6·5 | | At roof. |
| | ,, | 3·6 | 18·8° | 13·8° | 7·2 | 0·4 | Fire much lower. Draught = 3,260 cubic ft. per hour. |
| | ,, | 3·6 | | | 7·2 | | At roof. |
| Room B.—786 cubic ft. Attic of irregular shape on second floor. One window. Walls papered. | 1·32 | 1·5 | 17·8° | 11·0° | 20·1 | 1·8 | Wind imperceptible throughout experiment |
| | ,, | 1·5 | | | 28·2 | | At roof. |
| | ,, | 2·3 | | | 24·4 | 1·8 | |
| | ,, | 2·3 | | | 26·0 | | At roof. |
| | ,, | 3·2 | 17·8° | 10·5° | 22·2 | 1·2 | |
| | ,, | 3·2 | | | 26·9 | | At roof. |
| Room C.—1,100 cubic ft., 11·5 ft. high and nearly square. A laboratory room on ground floor. One window and one outside wall of sandstone. One inside wall of sandstone, and other two of wood and plaster. Walls not papered. One fixed ventilator at roof. Opening about 24 square in. Left open through both experiments. | 0·94 | 0·0 | 13·5° | 11·5° | 3·0 | | Wind scarcely perceptible. |
| | ,, | 1·0 | | | 10·3 | 2·9 | |
| | ,, | 2·0 | | | 11·9 | 1·3 | |
| | ,, | 3·25 | | | 13·4 | 1·3 | |
| | ,, | 6·0 | | | 16·0 | 1·5 | |
| | ,, | 8·0 | 13·6° | 9·0° | 16·1 | 1·5 | |

## Appendix II.—*continued.*

| Description of room. | Cubic ft. of $CO_2$ formed per hour. | Hours since candles lighted. | Temperature Centigrade. Ins. | Out. | Volume of $CO_2$ per 10,000. | Hours required for a volume of air equal to that of the room to enter. | Remarks. |
|---|---|---|---|---|---|---|---|
| Same room. - - - | 1·41 | 1·75 | 17·2° | 14·5° | 5·7 | 0·25 | Strong wind throughout experiment. |
| | ,, | 3·3 | | | 6·3 | 0·3 | |
| | ,, | 4·0 | | | 5·3 | 0·25 | |
| Room D.—5,600 cubic ft. 11·5 ft. high and nearly square. Laboratory room on ground floor. Two double windows and one outside wall of sandstone. One inside wall brick, one of sandstone, and one of wood and plaster. No fireplace. Room not papered. | 1·41 | 0·6 | 13·8° | 11·8° | 4·6 | — | Wind scarcely perceptible. Simultaneous with first experiments on Rooms C and E. |
| | ,, | 1·25 | | | 5·7 | 4·2 | |
| | ,, | 2·7 | | | 8·1 | 4·6 | |
| | ,, | 4·0 | | | 10·0 | 5·2 | |
| | ,, | 4·7 | | | 10·5 | 4·8 | |
| | ,, | 7·5 | | | 12·2 | 4·5 | |
| | ,, | 9·25 | 14·0° | 9·2° | 12·4 | 4·1 | |
| Same room - - - | 2·82 | 1·6 | | | 8·4 | 1·9 | Strong wind. Simultaneous with second experiments on Rooms C and E. |
| | ,, | 2·4 | | | 9·2 | 1·6 | |
| | ,, | 3·2 | | | 10·3 | 1·8 | |
| | ,, | 3·8 | 17·8° | 14·5° | 10·1 | 1·4 | |
| Room E.—18,800 cubic ft. 11·5 ft. high, and 70 × 24 ft. A long laboratory room on ground floor. Windows and four doors. 70 % of wall is to outside, and of sandstone. Otherwise like room D. | 7·5 | 0·0 | | | 3·0 | | Wind scarcely perceptible. Simultaneous with first experiments on Rooms D and C. |
| | ,, | 0·5 | 13·5° | 11·8° | 5·3 | — | |
| | ,, | 1·0 | | | 7·2 | — | |
| | ,, | 2·2 | | | 8·4 | 2·0 | |
| | ,, | 3·5 | | | 10·6 | 2·5 | At roof. |
| | ,, | 4·2 | | | 10·3 | | At one end of room. |
| | ,, | 4·5 | | | 10·3 | | |
| | ,, | 5·2 | | | 10·6 | 2·1 | |
| | ,, | 7·2 | 13·5° | 9·2° | 10·1 | 1·8 | |
| Same room. - - - | — | — | | | — | — | Strong wind. Simultaneous with second experiments on Rooms C and D. |
| | 14·7 | 1·4 | | | 10·8 | 2·0 | |
| | ,, | 2·0 | | | 11·6 | 1·5 | |
| | ,, | 2·8 | | | 12·7 | 1·5 | |
| | ,, | 3·6 | 17·5° | 14·5° | 15·2 | 1·8 | Wind now less strong. |
| | ,, | 4·2 | | | 14·7 | 1·6 | Wind stronger again. |
| Room F.—13,300 cubic ft. 15 ft. high and nearly square. A large ground floor room in Auchterarder, used as a gymnasium. One large open fireplace and two doors. Walls of stone. | 4·7 | 0·0 | 16·8° | 15·6° | 3·2 | | Gentle breeze throughout experiment. Very perceptible draught up chimney, but fire not lit. Simultaneous with first experiment on Room G. |
| | ,, | 3·0 | | | 9·7 | 2·9 | |
| | ,, | 4·8 | | | 9·4 | 1·9 | |
| | ,, | 6·2 | 17·8° | 14·0° | 9·7 | 1·9 | |
| | ,, | 6·7 | | | 9·9 | 1·9 | |
| Room G.—75,000 cubic ft. 79 × 40 ft and 30 ft. high in centre. Town hall of Auchterarder. Gallery behind, about 15 ft. high in centre. Stone walls. Sloping roof with skylights. Ventilators closed. | 24·5 | 0·0 | 15·5° | 14·4° | 3·1 | | Gentle easterly breeze through experiment. |
| | ,, | 3·8 | 16·8° | 14·0° | 9·0 | 2·3 | |
| | ,, | 4·0 | | | 9·3 | 2·4 | |
| | ,, | 5·7 | 17·0° | 13·3° | 9·6 | 2·1 | |
| | ,, | 7·5 | | | 10·4 | 2·2 | |
| | ,, | 8·2 | | | 9·5 | 2·0 | |
| | ,, | 8·5 | 17·0° | 12·2° | 9·9 | 2·1 | |
| | 15·2 | 0·0 | 16·0° | 16·7 | 2·9 | — | Wind scarcely perceptible. |
| | ,, | 1·0 | | | 4·3 | — | |
| Same room - - - | ,, | 1·0 | | | 4·6 | — | Middle of gallery. |
| | ,, | 2·0 | | | 6·0 | 3·3 | |
| | ,, | 2·1 | | | 6·2 | — | Middle of gallery. |
| | ,, | 2·8 | 17·5° | 16·5 | 6·2<br>6·4 | 2·5 | |

## Appendix II.—*continued.*

| Description of room. | Cubic ft. of $CO_2$ formed per hour. | Hours since candles lighted. | Temperature Centigrade. Ins. | Temperature Centigrade. Out. | Volumes of $CO_2$ per 10,000 | Hours required for a volume of air equal to that of the room to enter. | Remarks. |
|---|---|---|---|---|---|---|---|
| Same room. | 15·2 | 3·0 | 18·2° | 16·5° | 6·7 | — | Middle of gallery. |
| | „ | 3·7 | | | 6·9 | 2·6 | |
| | „ | 4·0 | | | 7·9 | — | Platform in front of hall. |
| | „ | 4·1 | | | 7·3 | 2·7 | |
| | „ | 4·3 | | | 8·4 | — | Middle of gallery. |
| | „ | 4·8 | | | 8·8 | — | Platform. |
| | „ | 4·9 | 18·5° | 17·3° | 7·9 | 3·0 | |
| | „ | 5·2 | 17·8° | | 9·3 | — | Gallery. |
| | „ | 5·5 | | | 9·6 | — | Platform. |
| | „ | 5·6 | | | 8·3 | 3·2 | |
| | „ | 6·0 | | | 10·1 | — | Platform. |
| | „ | 6·2 | | | 9·0 | — | Gallery. |
| | „ | 6·5 | | | 9 9 | — | Platform. |
| | „ | 6·6 | | | 9·0 | 3·5 | |
| Room H.—72,000 cubic ft. $57\frac{1}{2} \times 46\frac{1}{2}$ ft., and 28 ft. high in centre. Free church, Auchterarder. | 15·0 | 0·0 | 11·7° | 12·7° | 3·1 | — | Gentle N. W. breeze. Air entering by loosely fitting windows on west side. |
| Gallery round three sides, and about 15 ft. high in centre. Lighted by windows. Ventilated by openings measuring about 46 square ft. in all, and communicating with loft below slates. Side windows. | „ | 1·1 | | | 5·5 | — | Back of gallery. |
| | „ | 1·2 | | | 5·1 | 2·8 | |
| | „ | 2·0 | | | 6·9 | — | Back of gallery. |
| | „ | 2·1 | | | 6·2 | 3·1 | |
| | „ | 2·9 | | | 6·0 | — | West side of body. |
| | „ | 3·0 | | | 7·9 | — | East side of body. |
| | „ | 3·1 | | | 7·2 | 3·3 | |
| | „ | 3·4 | | | 7·5 | — | Back gallery. |
| | „ | 4·5 | | | 7·5 | 2·7 | |
| | „ | 4·6 | | | 7·3 | — | Back gallery. |
| | „ | 4·7 | | | 6·4 | — | West gallery. |
| | „ | 4·8 | | | 7·3 | — | East gallery. |
| | „ | 5·5 | | | 7·2 | 2·2 | |

In addition to the experiments with candles in rooms C and D, a number of others had previously been made by the method of allowing coal-gas, instead of carbonic acid, to escape into the room at a known rate. The full details are given at p. 86 in Appendix I. of the Report of the Water Gas Committee, 1899. In several cases the percentage of coal-gas in the air at the roof and at 4 feet from the floor became practically the same after a few hours, and these experiments are therefore available for calculating the rate of natural ventilation. In the experiments on room C, the small ventilator near the roof was closed. The results of the available experiments were as follows :—

| | Rate of escape of gas in cubic ft. per hour. | Duration of escape in hours. | Percentage of gas in the air. At 4ft. from floor. | Percentage of gas in the air. At roof. | Hours required for a volume of air equal to that of the room to enter. | Remarks. |
|---|---|---|---|---|---|---|
| Room C, 1,100 cubic ft. | 10·2 | 8·2 | 1·45 | 1·40 | 1·6 | Slight breeze—13 deg. inside and 8 deg. outside. |
| | 10·2 | 9·2 | 1·35 | — | 1·5 | |
| Room C - - - | 11·6 | 9·3 | 2·74 | 2 54 | 2·4 | No breeze—13·9 deg. inside and 4·5 deg. outside. |
| Room D, 5,700 cubic ft. | 14·0 | 7·9 | 0·77 | 0·74 | 3·0 | Little breeze—13 deg. inside and 5 deg. outside. |
| | 11·8 | 11·2 | 0·71 | — | 3·4 | |

## Appendix II.—*continued.*

Taking first the case of rooms with no fireplace openings, it will be seen that in the small rooms of about 1,200 to 1,400 cubic feet with a boarded floor above, only one outside wall, all openings closed (Room A and Room C in the experiments with gas), and no appreciable wind the air of the room was changed about once in two or three hours, while in the larger room of the same character (Room D) the rate of change was once in three to five hours. It is evident that the form and general construction being the same, the larger a room the more slowly will the air in it be changed by penetration of air through the walls, etc., for the extent of walls, roof and floor surface does not increase in the same proportion as the cubic capacity. The surface increases as the square, and the capacity as the cube, of any corresponding diameter for rooms of the same shape. Thus an increase of eight times in the capacity will correspond to increase of only four times in the surface. Very large rooms, when unprovided with openings for ventilation, may thus contain very foul air, although the air space per person is very large. Striking examples of this are provided in Apendix I., particularly in Table O, Nos. 28-61. (Spinning). Thus in one spinning-room of 91,500 cubic feet, containing only 9 persons as sources of vitiation, the carbonic acid during the day was found to rise as high as 16·5 volumes per 10,000 (No. 46), and this in spite of the fact that the temperature was extremely high (92 deg.), which would naturally favour the exchange of air; when gas was being used in the early morning and evening the carbonic acid in the day was 46 volumes in this room (No. 43), and 56·5 in the evening with gas actually burning. The rate of change of air was evidently not more than about once in 24 hours. The apparently anomalous fact that we found the proportion of carbonic acid on the whole as high with a large as with a small air space per person (*see* above) is to a great extent explained by the fact that the rooms with a large air space per person were relatively very large. In the larger rooms, however, other circumstances, such as a more permeable roof, or a larger extent of outside wall, may favour the ventilation, as in Rooms E, F, G, H.

The influence of wind increasing the natural ventilation through walls, etc., is clearly shown in the candle experiments. In Rooms A, C and D the ventilation was increased by from two to six times by a strong wind.

Difference of temperature between inside and outside must increase the exchange of air between inside and outside, particularly if the roof is easily penetrated by air. The effects of temperature differences are not, however, very apparent in the candle experiments, and it must be remembered that in rooms of average height the effect of any ordinary difference of temperature in causing air to pass through walls and chinks is probably slight as compared with the influence of wind. With a room of average height a gentle breeze of ten miles an hour will have far more effect than a difference of temperature of 20 deg. F. The effects of temperature differences are however, very clearly seen in the case of the Scotch weaving shed (Table P, Nos. 1 to 17, App. I.) where the ventilation was about three times as great with a temperature difference of about 18 deg. F. as when there was no difference.

The influence of an open chimney, with or without a fire burning in it, is very distinct in the experiments on Room A. A bright fire increased the ventilation of room A as much as ten times, whereas the mere opening of the flap of the grate doubled the ventilation.

The experiments in Rooms G and H indicate that a roof which is easily permeable to air makes a great difference. In spite of their relatively large size the air of the church H and hall G, which had easily permeable roofs, was changed about once in three hours. The influence of an air-tight roof is also very distinctly shown in one of the weaving sheds (Table M, Nos. 22 to 34). This was covered with water, and there were no windows open, or other means of ventilation, with the result that, though each person had 1,620 cubic feet of air space and no gas was being used; the carbonic acid during the day gradually rose to 33 volumes per 10,000, and was still rising when work ceased. This result may be contrasted with that found in No. 10 of the same table, or in the Scotch shed, Table P, where, with an ordinary roof and nearly all ventilators closed, the carbonic acid during the day only rose to about 6 volumes, and had reached this point after an hour of occupation.

Taken as a whole the experiments indicate that in small rooms, provided there is an open chimney, no gas burning, and an air space of not less than 1,000 cubic feet per person, the ventilation may often be fairly sufficient without open windows or other special means of ventilation. With a good coal fire burning in the grate the ventilation is likely to be fair, even with only 400 cubic feet of air space per person. The larger the size of the room, however, the greater becomes the need of special openings

## Appendix II.—*continued.*

for ventilation ; and in rooms of over 5,000 cubic feet open windows or special ventilators are nearly always necessary unless the air space per person is very large or the roof is very permeable to air. In large and crowded rooms it is very difficult to provide adequate ventilation at all times except by the use of fans ; but the observations on the Scotch weaving shed just referred to show that excellent results can be attained without mechanical ventilation even in a very large room if there is no crowding, and the manufacture is not affected by external variations of atmosphere.

The difficulty in ventilating crowded rooms, if fairly large, without fans is well illustrated by the notoriously bad ventilation of elementary schools. The average proportion of carbonic acid in elementary schools without fan-ventilation was found to be 18·6 during the winter months, with an average of 186 cubic feet of air space per child, and 15,450 cubic feet per room*.

### Natural Ventilation Through Special Openings.

Where special openings for ventilation of workshops and factories are used these are in the great majority of cases open windows. As a general rule this seems to be the most practical arrangement in ordinary buildings. Where permanent openings such as ventilation shafts are also provided we have frequently observed that these are either totally insufficient in number or size, or have been blocked up in cold or windy weather, and left in this condition. It is evident that where windows are used for natural ventilation they require constant regulation, as their action is entirely dependent on the varying influence of wind and differences of temperature between inside and outside. Not only must the extent be varied to which any particular window, or set of windows is opened, but often it is necessary to close those facing in one direction and open those on the other side. The most suitable arrangement of windows varies so much in different kinds of rooms that it is impossible to lay down rules on the subject. The windows should, however, always open at as high a point as possible, with a view both to avoidance of draughts and to allowing of the more ready escape of the heated air from lights and persons. Windows so arranged that the incoming air can be directed upwards are advantageous in winter, but should when possible be capable of being opened as freely in summer as ordinary sliding sashes. The free opening of windows in summer is an enormous advantage.

Where open windows are used as outlets it not infrequently happens that a staircase, or the shaft of a lift, is the principal inlet. If the air thus entering has been more or less warmed by passing through a basement or ground floor room which is heated in winter this arrangement is successful ; but often enough, as already pointed out, the foul air from one flat is allowed to pass up into the next, so that the incoming air for the higher flat is far too impure.

The opening and closing of windows ought not to be left solely in the hands of ordinary workpeople, but a foreman or other person in each room should be made responsible for having enough of windows open to keep the air fresh without causing inconvenience from cold and draughts, and for seeing to the proper regulation of the heating arrangements. The freshness of the air can best be judged of on entering the room from the outside air ; and for the regulation of temperature a thermometer should be used.

In very wide rooms, sheds, etc., ventilation is usually carried out by means of special ventilators or shafts in the roof, often supplemented by Tobin tubes or other inlet openings. Where ventilation is mainly dependent on this plan it is essential that the openings should be sufficient in number and cross section to perform their work even on still and warm days. Roughly speaking a greater velocity than about 200 feet per minute up a ventilating shaft cannot usually be counted on, even with free entrance of air to the room. A cylindrical shaft of one foot in diameter has an area of nearly ·8 cubic feet, and will therefore carry off about $200 \times 60 \times \cdot 8 = 9{,}600$ cubic feet of air per hour. Hence to give a ventilation of about 2,000 cubic feet per person per hour, one such outlet ventilator would be needed for every five persons, or one square foot of free outlet shaft for every six persons, together with corresponding inlet provision. We have observed that the provision of ventilating shafts is frequently quite insufficient. Often, too, the shafts are so obstructed by various elaborate contrivances above, or in the course of the shaft that they are of very little use except in windy weather, when they are least needed, as natural ventilation by other means is

(*) Carnelley, Haldane, and Anderson, Philosophical Transactions, 1887, B. p. 79.

## Appendix II.—*continued*

then at its maximun. It is unfortunate that ventilation is frequently regarded from a qualitative rather than a quantitative aspect. Arrangements which are well designed with a view to prevention of draughts in cold weather, or to utilising the effects of wind, are often quite insufficient to give the necessary quantity of air in warm or still weather, so that unless windows are freely opened the ventilation may be very bad. If the ventilators are designed so as only to give sufficient air in cold or windy weather they will not give nearly enough in still weather ; and if they give enough in still and warm weather they will usually cause draughts in cold and windy weather unless they are partially closed. The truth is that natural ventilation, whether by means of shafts, etc., or by open windows, needs constant regulation and attention ; and in factories and workshops employers should make such arrangements that not only are sufficient means of ventilation provided for all weathers, but that some one person is definitely responsible for their regulation in each room. From what we have observed we are convinced that under these conditions it is easy enough, where a room is not crowded, to keep the air fresh, and consequently well within the carbonic acid limit recommended by the Committee, and that no hardship would be imposed on employers by this limit provided the regulation were interpreted in a reasonable spirit and with due regard to the difficulty of avoiding occasional mistakes.

The more crowded a room is, the less easy does it become to secure adequate supply and distribution of air without the use of fans. A great deal will, however, depend on the adequacy of the heating arrangements, the situation of the windows or other openings, and the possibilities of using them for ventilation without causing intolerable draughts. In cases where, after due notice of inadequate ventilation has been given, the air is not kept within the proposed limits of purity, we are very decidedly of opinion that the employer can be fairly called upon to provide adequate mechanical or other ventilation, with the inlets and outlets so arranged as to avoid draughts, or else to reduce the number of persons employed in the room.

### Ventilation by Fans.

Ventilation by fans has the great advantages that (1) practically unlimited quantities of air can be supplied ; (2) the supply is completely under control, so that it can always be relied on ; (3) the incoming air can be warmed, moistened, or filtered from soot ; (4) dust and fumes can be removed at or near the points where they are given off. These advantages are so great as compared with the cost involved that where engine power or electricity is available mechanical ventilation is now very largely used in factory ventilation, even in rooms which are not crowded.

A fan may be placed in either an inlet or an outlet for air, the best arrangement for any particular case depending on circumstances. If it is necessary to warm, filter, or moisten the incoming air, the fan should, as a rule, be in an inlet, so that no untreated air can enter the room. On the other hand, if the incoming air has not to be treated the most convenient position is usually in an outlet placed high up. The incoming air then enters through the walls, roof and various openings. The incoming air currents should be so directed and sub-divided as to secure proper distribution of air and reduce draught to a minimum. In rooms of great superficial area several fans are needed to secure proper distribution ; and often a combination of inlet and outlet fans is advantageous. Where a fan is used for the removal of dust, steam or fumes which are escaping into the air and cannot be dealt with at their point of origin, the fan should be placed so as to draw off the vitiated air as directly as possible, and particularly not to draw it across the room. Mistakes as to this point are not infrequent. Proper heating arrangements must of course be combined with fan ventilation, whether or not the incoming air is heated.

For purposes of general ventilation, where the difference of pressure on the two sides of the fan is, or ought to be, practically inappreciable, fans of the simplest construction, and with a minimum of internal resistance, are employed. They are usually of the propeller type. The propeller fan resembles the screw-propeller of a steamer, and is set in a circular opening, through which the air is propelled by the rotation of the fan. Assuming that there is no difference of pressure in the air on the two sides of the fan, the whole of the energy communicated by the motor to the fan, with the exception of what is wasted in friction, is expended in setting the air in motion. Part of this motion is, however, lateral, and therefore useless, so that with a propeller fan only about about 40 per cent. of the energy communicated to the

## Appendix II.—*continued.*

air, or less, is expended in driving it in the required direction parallel to the axis of the fan*. Even so, however, the volume of air which can be propelled with a trifling expenditure of power is enormous. The number of foot pounds (F.P.) of work communicated to the air per second in driving it forwards is $\frac{WV^2}{2g}$ where

W = weight in pounds of air moved per second,
V = velocity of air-current forwards in feet per second,
g = acceleration due to gravity in feet per second;

but one cubic foot of air weighs about ·078 lbs., and g = 32·2, hence, if Vol. = volume of air moved in cubic feet per second, the formula becomes

$$\text{F.P.} = \frac{\text{Vol.} \times \cdot 078 \times V^2}{64 \cdot 4} = \text{Vol.} \times V^2 \times \cdot 00121.$$

Hence, if the opening of the fan is 2 feet in diameter, or 3·14 square feet in area, and the volume of air delivered is 40 cubic ft. per second, or 144,000 feet per hour, so that the velocity through the opening is $\frac{40}{3 \cdot 14}$ or 12·7 feet per second, the foot-pounds per second of work expended in driving forward the air will be $40 \times 12 \cdot 7^2 \times \cdot 00121 = 7 \cdot 8$. This is equivalent to 468 foot pounds per minute, or $\frac{468}{33{,}000} = 0 \cdot 0142$ horse power. Assuming that about 20 per cent. of the energy communicated from the driving belt to the fan is utilised in driving forward the air, the horse power required to drive the fan will be only 0·07.

The volume of air moved by a fan varies directly as its rate of revolution, and the work done on the air varies as the square of the velocity of the air-current, so that the work done by the fan varies as the cube of its rate of revolution. It is thus an economy of power, as well as of wear and tear, to employ a fan of sufficient size not to require a very high rate of speed.

When a fan is working against resistance the energy expended in driving forwards the air is greatly increased, and with a certain back-pressure a fan working at a given velocity will practically cease to drive forward any air. With propeller fans in particular, this limit is very soon reached; for since the velocity with which the blades are moving is much less at the centre than at the periphery of the fan, a much smaller pressure will suffice to drive air backwards through the centre than at the periphery, so that with increasing resistance there is more and more loss of useful effect from this cause, and finally the fan is practically churning air round and round within itself. We have frequently observed fans which were inefficient from this cause. Where a propeller fan, or duct leading outwards from it, opens on the side of a building exposed to wind the pressure of the wind may easily cause so much air to blow backwards through the centre of the fan that the current is for the time completely reversed. We have observed this, for instance, in the case of a fan used for removing dust. The latter was being blown in the face of the workmen instead of being drawn off. The fan was too large for the work required of it, and was consequently being run at a very low velocity. The passage of air backwards through the centre of a propellor fan can be remedied without increasing the speed by blocking the central part, which is of little use under any circumstances. The fan will then work efficiently against a much greater adverse pressure.

Where the fan is not completely boxed in by a surrounding tube, and the blades are not so constructed as to prevent lateral escape of air, adverse pressure from wind or other resistance will cause the air to escape laterally instead of being driven through the fan. If this escape occurs on the side of the fan from which the air is coming its efficiency may be almost completely destroyed. It may thus happen that a fan placed in a certain position will drive air efficiently in one direction, but not in the opposite direction.

When a fan is exhausting or propelling air through a duct it is evidently of great importance to keep the resistance offered by the duct within a reasonable limit. The resistance depends largely on the work expended in imparting velocity to the air, and

* With a simple three-bladed fan, 2 feet in diameter and revolving 600 times per minute, Mr. W. G. Walker found that with the best arrangement of blades 42·8 per cent. of the energy communicated to the air by the fan was expended in driving it forwards. The fan was delivering 2,420 feet of air per minute, and the horse power communicated to the air was ·0334 (Proc. Inst. of Mechan. Engineers, Nov. 1897.)

## Appendix II.—*continued.*

this work, as already seen, increases in proportion to the square of the velocity of the air current. Hence it is very important that the duct should be of such a size at all points that the velocity is moderate. As a general rule a duct or its combined branches ought to have a cross-sectional area equal to, or somewhat greater than that of the fan opening; and where, as often occurs, it is necessary to restrict the size of the ducts and use rapid air currents, a form of fan with correspondingly restricted opening, and working efficiently against correspondingly increased pressure, should be employed. An ordinary open propeller fan is useless in such a case, for the reasons just explained, and a centrifugal fan is best. For the purposes of general ventilation, however, it is evidently preferable to employ fans and ducts with wide openings, and to run the fan at the lowest velocity which will secure under all conditions a sufficient air current. It should also be borne in mind that at every point which the air has to pass at an increased velocity due to narrowing or obstruction of the duct there is great increase of the work required to move the air, since the work increases as the square of the velocity. If a propeller fan 2 feet in diameter, or 3·14 square feet in area, is drawing its air supply through a duct narrowed at one point to 1 square foot in area, the output of the fan, when running at a given velocity, has been found to be reduced to about a third of what it would otherwise be.

A rectangular bend in a duct has been found to produce a resistance equivalent to that caused by an increase of nearly 50 per cent. in the velocity, or 100 per cent. in the pressure needed merely to set the air in motion at the same velocity. Sharp bends should therefore be avoided wherever possible. The loss at a bend is greatly diminished by making it gradual. There is also a loss at the entrance of a duct equivalent to that caused by an increase of nearly a third in the velocity, unless the opening is trumpet-shaped.

Frictional resistance of the duct walls must also be taken into account. Its amount is proportional to the total internal surface of the duct, but inversely proportional to the sectional area. It follows that the duct should, so far as possible, be of such a shape as to present a minimum of internal surface with a maximum of sectional area, and that it is disadvantageous to sub-divide an air current between several ducts. Frictional resistance depends also on the velocity of the air current. When the walls of a duct are perfectly smooth, as in the case of a glass tube, the resistance varies directly as the velocity of the air current. Where, as is almost always the case in practice, the walls are not very smooth, the resistance increases or diminishes more rapidly than in direct proportion to the velocity, but not so rapidly as in proportion to the square of the velocity. The resistance from friction thus does not vary with the velocity according to the same law as the resistance due to the work required merely to impart motion to the air; and frictional resistance is of greater *relative* importance with slow than with rapid air currents and is also much more important with long than with short ducts. It can often be more advantageously overcome by increasing the driving pressure than by increasing the sectional area of a duct.

Where there are several openings for the passage of air into or out of a duct these should be properly proportioned to give the required flow at each. This is best done empirically, with the help of an anemometer, or by using the flame of a candle or taper to judge of the velocity of the current at each opening

All air-ducts should be accessible for inspection and cleaning, particularly if there is much dust in the air Accumulations of dust may greatly diminish the flow of air through a duct.

# APPENDIX III.

## Determination of Carbonic Acid in the Air of Factories and Workshops.

# APPENDIX III.

## Determination of Carbonic Acid in the Air of Factories and Workshops.

Contents.

# APPENDIX III.

## DETERMINATION OF CARBONIC ACID IN THE AIR OF FACTORIES AND WORKSHOPS.

### 1.— *Description of Apparatus.*

The apparatus referred to in the Report is shown in Figures 1, 2 and 3. Figures 1 and 2 are sections drawn to scale. It is enclosed in a wooden case, the internal measurements of which are $6\frac{1}{2} \times 12 \times 2\frac{1}{2}$ inches. The weight when the whole is ready for use is about 5 pounds.

The air burette A, which is enclosed in a water jacket with glass face, consists of a wide ungraduated and a very narrow graduated portion. It holds about 20 c.c. from the tap to the bottom of the scale. The graduated part, which is 4 inches long, is divided into about 100 divisions, each of which corresponds to $\frac{1}{10,000}$th part of the capacity of the burette, when moist, for mercury. The lowest division is marked 0. Any difference between a reading at or near zero, and a second reading is thus shown by the scale in volumes per 10,000, there being no calculations or corrections.

The more important dimensions are :—

| | |
|---|---|
| Internal measurement of water jacket - - | $2\frac{1}{2} \times 1\frac{1}{2} \times 7$ inches. |
| Width of shelves - - - - - - - - - | 2 " |
| Distance from floor of case to bottom of lower shelf - | $2\frac{1}{2}$ " |
| " " " " " upper shelf - - | $9\frac{7}{8}$ " |
| Thickness of wood - - - - - - - - | $\frac{3}{8}$ " |

Capacity of bulbs about 25 c.c. Diameter about 1·5 inches.

Diameter of wide part of burette and control tube about 1 inch. Capacity about 20 c.c. Internal diameter of connecting tube to potash 1·9 to 2·2 m.m.

Extent of graduated portion of burette 4 inches from bottom of wide part, with from 90 to 110 divisions. Internal diameter 1·5 to 1·7 m.m.

Internal diameter of tube of potash reservoir and rubber connections, about 4 m m.

The case is white inside to facilitate observation of the marks on the tubes.

The corks closing the water jacket above fit loosely, so that air can easily escape.

In using the apparatus the air is first expelled from the burette by opening the three-way tap B to the outside, and raising the mercury bulb C. The latter is then lowered and placed on the hook of the rack and pinion arrangement F, so that a sample of the air is drawn in, and the level of the mercury falls to near the zero mark. The tap is now opened towards the absorption pipette D, which is filled to a mark at E with caustic potash or soda solution (about 10 per cent.), and the sample measured with the precautions to be described below. It is then passed over into the absorption pipette, driven partially backwards and forwards two or three times, and again measured after the absorption of the carbonic acid. The difference between the two readings gives directly the number of volumes of carbonic acid per 10,000 in the sample of air.

It is evident that the correctness of the analysis depends entirely on the avoidance of errors of various kinds in the two determinations of the volume of the enclosed air. Mistakes might be caused by slight variations in the temperature of the water, or the pressure under which the sample is measured, or in the degree of saturation with moisture of the sample. A variation of 0·1 deg.C. in the temperature of the water in the jacket would, for instance, unless compensated, cause an error of fully 3 volumes per 10,000 in the analysis.

In order to have a sharp index of the pressure under which the air is measured, the level, not of the mercury, but of the potash solution in the narrow bore tubing of the absorption pipette, is taken as the index of pressure. At the first measurement the level is accurately adjusted to the mark E by raising or lowering the mercury by means of the rack and pinion arrangement F. At the second reading the potash level is again adjusted in the same way. As the potash has a specific gravity of only about a twelfth of that of mercury its level is a very delicate index of the

Appendix III.—*continued.*

pressure. A difference $\frac{1}{10\,000}$th part in the pressure would correspond to a difference of nearly 1 m.m. in the level of the potash solution, which would be very evident to the eye.

To compensate for variations in temperature of the water jacket a control tube G is employed, of a size and shape approximately the same as the burette and with similar connecting tubing. The control tube communicates with the potash through the narrow bore glass tube H, and before the first measurement is made the level of the potash in H is adjusted to the mark by lowering or raising the reservoir I, which slides up and down in a loosely fitting cork. At the second measurement the same precaution is taken, so that the air in the control tube occupies exactly the same volume as at the first measurement. As an alteration of temperature or of barometric pressure would affect the pressure to an equal extent in the burette and control tube it is evident that the adjustment of the level of the potash reservoir compensates exactly any error which the alteration of temperature or of barometric pressure would cause in the reading of the burette.

Before the adjustments of the potash levels are made, the water in the jacket is thoroughly mixed by blowing air through it by means of the tube K. This manipulation is absolutely essential. As error may sometimes arise from the potash tubes not being equally wetted above the marks, the rubber tubing should also be squeezed before a reading is taken, so as to momentarily raise the potash level by about 1 inch. Time must be allowed for the potash to assume its final position before the reading is made. If the levels do not rise and return sharply and equally there is grease or liquid in the taps or connecting tubes. The tubes E and H have an equal bore of about 2 m.m. If a narrower bore be employed error is sure to arise through the potash not returning sharply to a perfectly definite level when disturbed.

In order to obviate error due to variations in the saturation of the air both the burette and the control tube are left with a little visible moisture inside. If the burette has once been wetted inside, and as much as possible of the water expelled by raising the mercury, it remains moist for a very large number of analyses, but a little moisture should always be visible.

The accuracy of the graduation is tested by filling the burette, while moist, with mercury, and weighing what flows out between the points 0 and 50, 50 and 100, and 100 and the tap. A detached column of mercury should occupy the same number of divisions at all parts of the graduated tube of the burette. The efficient working of the apparatus is ascertained by depriving a sample of air of carbonic acid, and seeing that its volume as read off is not altered by more than about 0·5 of a division after it has been passed over into the potash pipette, as in an analysis. Any error due to leakage in the connections, or failure from any cause of the potash to return exactly to its proper position in the narrow bore tubing, will thus be at once revealed.

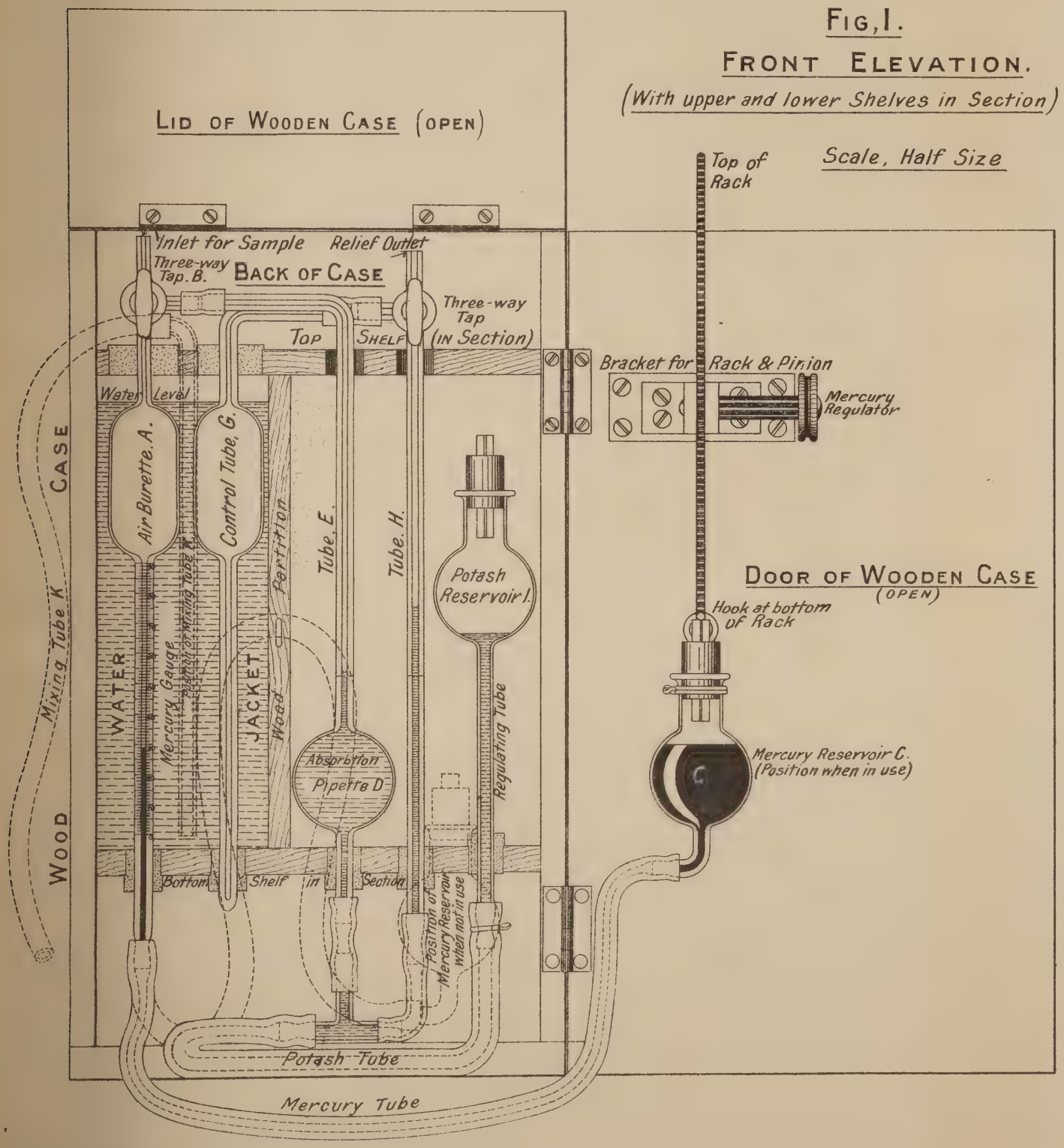
At the end of an analysis the taps must be turned so as to close the communications between the potash and the burette and control tube; otherwise potash may be sucked in if there is any considerable fall of temperature or rise of barometric pressure.

The apparatus is so arranged that it can be used either for taking and analysing on the spot samples of air, or for analysing at some convenient place samples which have been collected in small bottles. When the former method is used, the burette is filled with mercury, the tap turned sufficiently to close it without risk of potash being sucked over, and the mercury reservoir placed on the hook. The apparatus is then held or allowed to stand at the place where the sample is to be taken, and the tap opened, so that the sample is drawn in. During this process the breath should be held so as to avoid any risk of contaminating the sample with expired air.

The manipulations required during the analysis may be recapitulated as follows: (1) Open the tap of the control tube to the air for a moment, and then turn it so as to connect the control tube and potash pressure gauge. (2) Turn the tap of the burette so as to connect the burette and the potash pipette. (3) Squeeze the rubber tube of the potash reservoir so as to raise the potash level about an inch above the marks, and see that the level of the potash alters sharply and about equally in the two tubes. (4) Blow air through the water jacket. (5) Raise or lower the potash reservoir till the potash is exactly at the mark in tube H. (6) Raise or lower the mercury reservoir by means of the rack and pinion till the potash in E is exactly at the mark. (7) Read off the mercury level on the scale of the burette to ·2 of a division. (8) Raise the

# Dr. J. S. Haldane's Apparatus

## For Determining the Amount of Carbonic Acid per 10.000 Volumes of Air

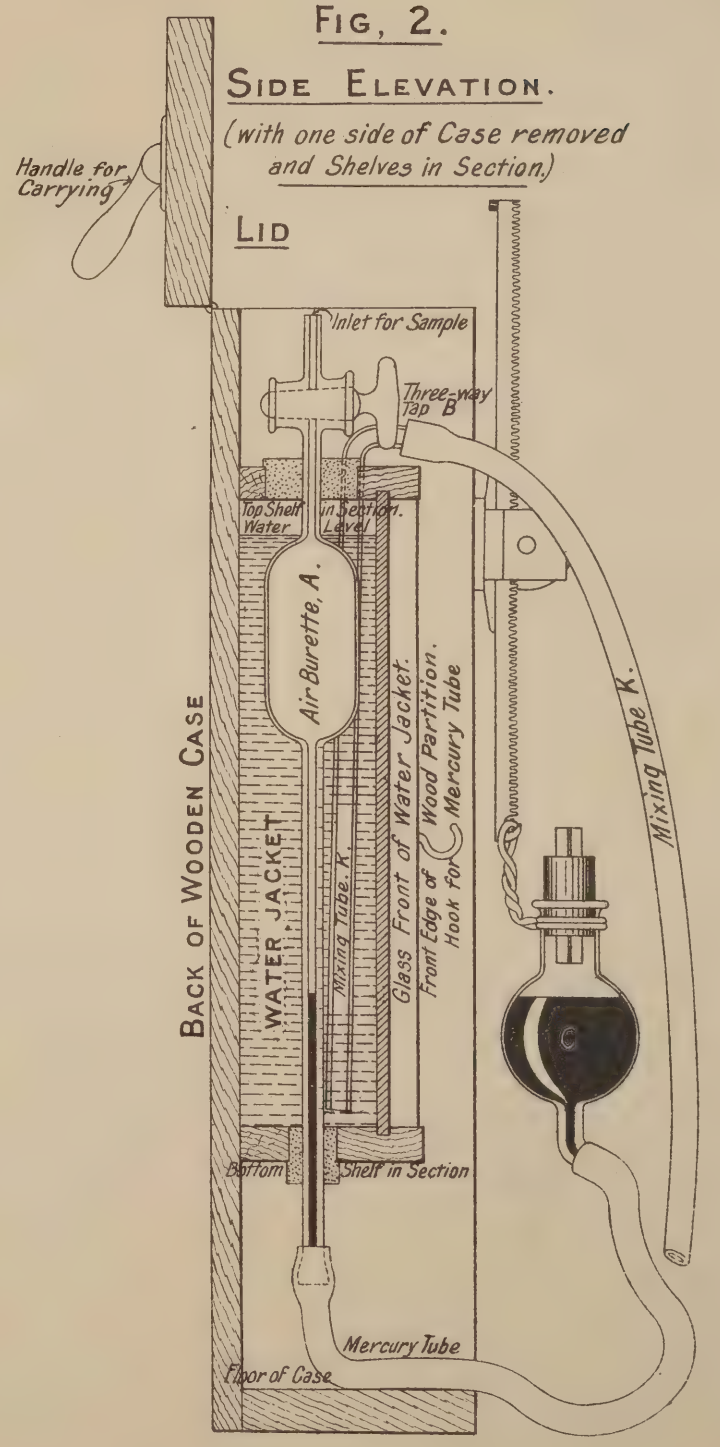



Fig, 1.

Front Elevation.

(With upper and lower Shelves in Section)

Scale, Half Size




Fig, 2.

Side Elevation.

(with one side of Case removed and Shelves in Section)

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Scale.

About 4in -1. Foot.

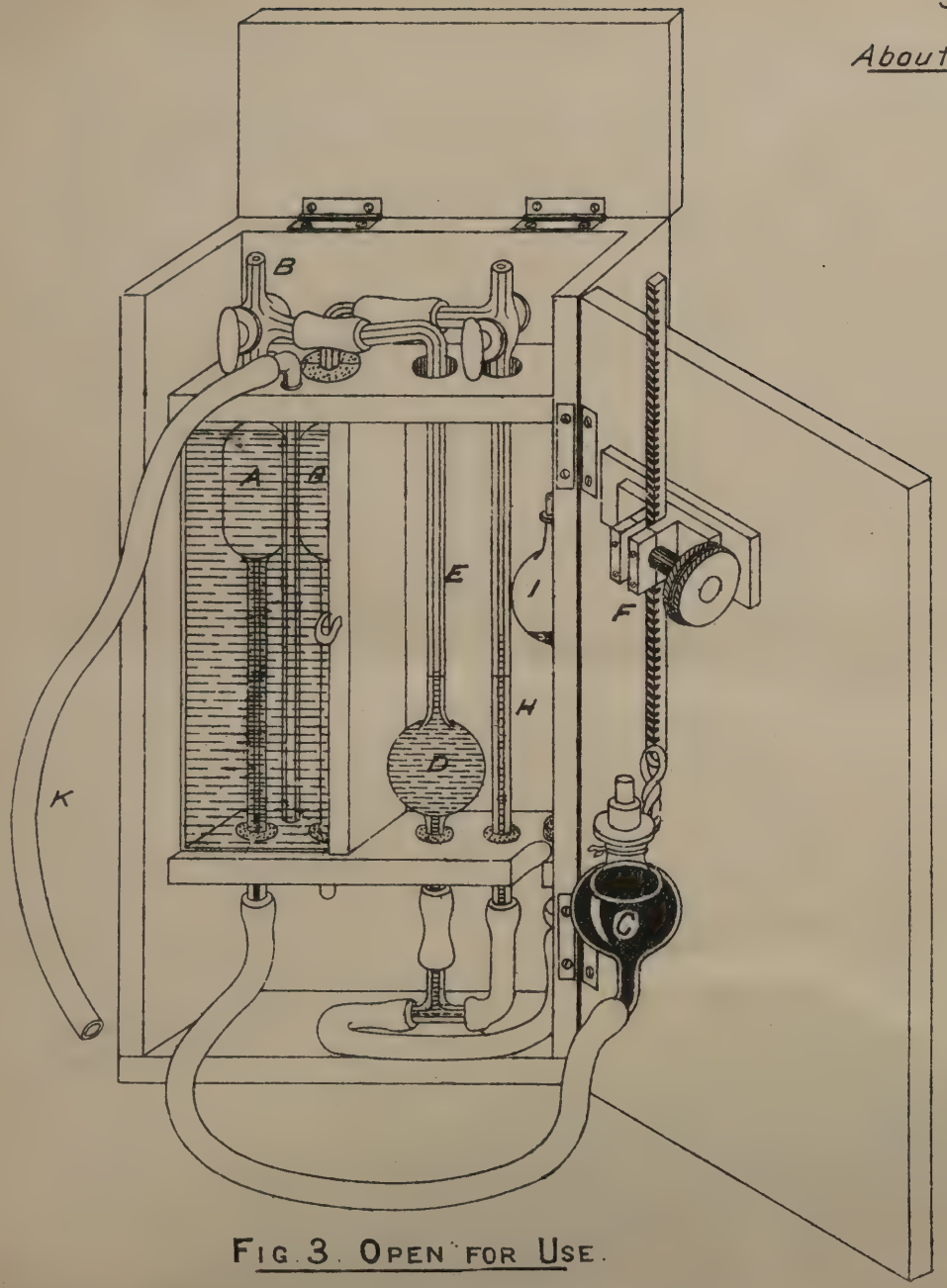


FIG. 3. OPEN FOR USE.

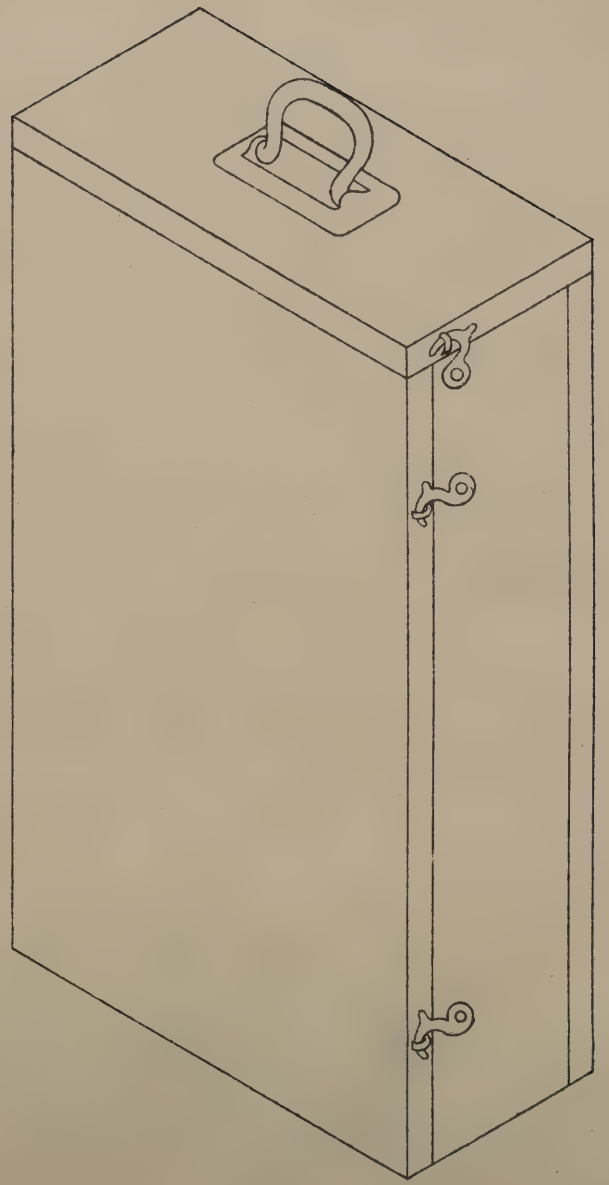

FIG. 3A. CLOSED FOR CARRYING.

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Appendix III.—*continued.*

mercury to the upper hook, so as to drive the air into the potash bulb ; then lower it a little and raise it twice again so as to wash any carbonic acid in the connecting tubing into the potash bulb. (9) Return the air to the burette. (10) Blow air through the water jacket. (11) Squeeze the tubing and adjust the two potash levels as before, and read off the mercury level. The first reading subtracted from the second gives the result in volumes per 10,000. (12) Turn the two taps so as to close the communication with the potash bulbs.

About four minutes are needed for the whole process.

Care is necessary to prevent potash being sucked over into the burette, or mercury passing over into the potash pipette. As already remarked the latter may easily occur if the apparatus is left with the communication between the burette and potash bulb open. If potash has been sucked over the mercury should be removed and replaced by very dilute sulphuric acid, with which the burette should be thoroughly washed out. The tap should also be cleaned and greased with fresh vaseline.

If mercury has passed over into the potash it must be removed by disconnecting the rubber tube below.

In filling the potash tube some trouble may arise from the presence of bubbles of air in the potash of the pressure gauge belonging to the control tube. These may be got rid of by repeatedly squeezing and relaxing the rubber tube so as to jerk the potash up and down.

When once the apparatus has been prepared for use it should remain always ready. A little water must, however, be occasionally syphoned into the water jacket to compensate for evaporation. The potash will last for hundreds of analyses without being recharged, but should be changed if the absorption becomes at all sluggish. In charging the apparatus with mercury it is important to see that no dirt gets into the burette from the rubber tubing. If any dirt appears it should be washed out with water. Should any black deposit from the mercury appear in the tube of the burette this may be removed by removing the mercury and rubber tubing, and gently sucking up nitric acid to the top of the graduated portion from a watch glass held below. No deposit should, however, form if the mercury is always replaced in its stand at the end of an analysis. The taps are lubricated with vaseline. The tap of the burette may be tested for tightness with the mercury. The tap of the control tube is tested by attaching a piece of rubber tubing to its free limb, and sucking. Any leakage would be indicated by movement of the potash in the pressure gauge. Care must be taken that neither tap becomes nearly blocked with vaseline. To prevent the mercury being spilt if the reservoir is inadvertently dropped, or the apparatus laid on its side, the reservoir has a cork fitted with a piece of glass tubing of capillary bore ; and there is a similar cork in the potash reservoir.

When the sample for analysis is collected separately in a small bottle, as described below, it is necessary to open the bottle with its mouth under mercury or water, and withdraw the air for analysis by means of a curved tube dipping under the liquid. If the air is withdrawn without delay water may be used without appreciable error ; but it will probably be found on taking a second sample from the same bottle that the proportion of carbonic acid has appreciably altered. Hence a second analysis is not reliable when water is used. The reason of the alteration is that carbonic acid is soluble in water, and will either diffuse from the water into the air, or from the air into the water, according to the proportions of the gas already present in the water and air,

When water is employed as the confining liquid a bent glass tube of the form shown in Fig. 4 may be used, the water being placed in an ordinary tumbler supported at a convenient height. The glass tube is attached by a short piece of rubber tubing to the top of the burette, and filled with mercury by raising the reservoir, the tap is turned sufficiently to close it without risk of potash being sucked over, and the reservoir placed on the hook. The stopper is then removed under the water and the tube introduced into the mouth of the bottle. On opening the tap a sample of the air is sucked in. The bottle and curved tube should then be slightly raised, so that the level of the water inside and outside the bottle, and consequently the pressure of the air, is the same. The analysis can now be completed in the manner already described. As more than one sample cannot be taken from the bottle it need not have a capacity of more than 1 oz.

## Appendix III.—*continued.*

When a double analysis may be desirable mercury should be used as the confining liquid. The most convenient plan is to use a wooden trough and glass tube of the form shown in Fig. 5. As, however, the sample is removed at negative pressure the mercury reservoir must be depressed below the level of the table before the tap is closed, so that the pressure is positive when the reservoir is placed on the hook. The excess of air can then be let out by opening to the air the extra three-way tap shown at A. After opening the extra tap it should be again closed and the reservoir raised, so that if any air has been caught at the lower end of the burette it is disengaged before the analysis is begun. The narrow slit reaching to the bottom of the trough should be $\frac{1}{4}$ inch wide, 6 inches long, and $4\frac{1}{2}$ inches deep. The wide part which receives the neck of the bottle is $1\frac{1}{4}$ inch wide, $2\frac{1}{2}$ inches long, and $1\frac{1}{4}$ inch deep. The trough is made by screwing together two pieces of compact wood, with marine glue between them to make the joint tight. When this trough is used the stopper may be removed after immersing the neck of the bottle in mercury contained in a small bowl. A Wedgwood mortar $3\frac{1}{2}$ inches in internal diameter is suitable. The bottle is closed with a finger and then transferred to the trough.

The following examples will serve to illustrate the degree of accuracy attainable with the apparatus :

I. Six successive analyses of outside air (country, winter) : samples collected in apparatus.

Vols. per 10,000.

(1) 2·8. (2) 3·2. (3) 3·3. (4) 2·7. (5) 3·3. (6) 2·8. Mean 3·0.

II. Three bottles of same outside air, collected simultaneously in bottles.
Bottle (1) 2·6. Bottle (2) 3·3. Bottle (3) 2·9. Mean 2·9.

III. Six successive analyses of samples from same bottle of vitiated air.
(1) 16·6. (2) 16·0. (3) 16·4. (4) 16·2. (5) 15·6. (6) 15·8. Mean 16·1.

IV. Three successive analyses of samples from same bottle of vitiated air.
(1) 51·0. (2) 50·8. (3) 51·4. Mean 51·1.

These examples show that with ordinary care the analyses may, after some practice, be relied on to within 0·5 volumes on either side of the right result.

### 2.—*Collection of Samples in Bottles.*

For collecting samples in bottles we have found the following method satisfactory and convenient.

The bottles used are ordinary 1oz. or 2oz. stoppered bottles. They must be both dry and clean, as when moisture and dirt are present there is risk of an appreciable amount of carbonic acid being gradually produced by bacterial action. The bottles should therefore be cleaned with a brush, rinsed with clean (preferably distilled) water, and completely dried. The stopper is greased with vaseline, and after the sample is taken should be turned round until no air-channels are visible between it and the neck of the bottle. The stopper is held in position by an elastic band passed over it, and a gummed label is placed on the bottle, as shown in Fig. 6.

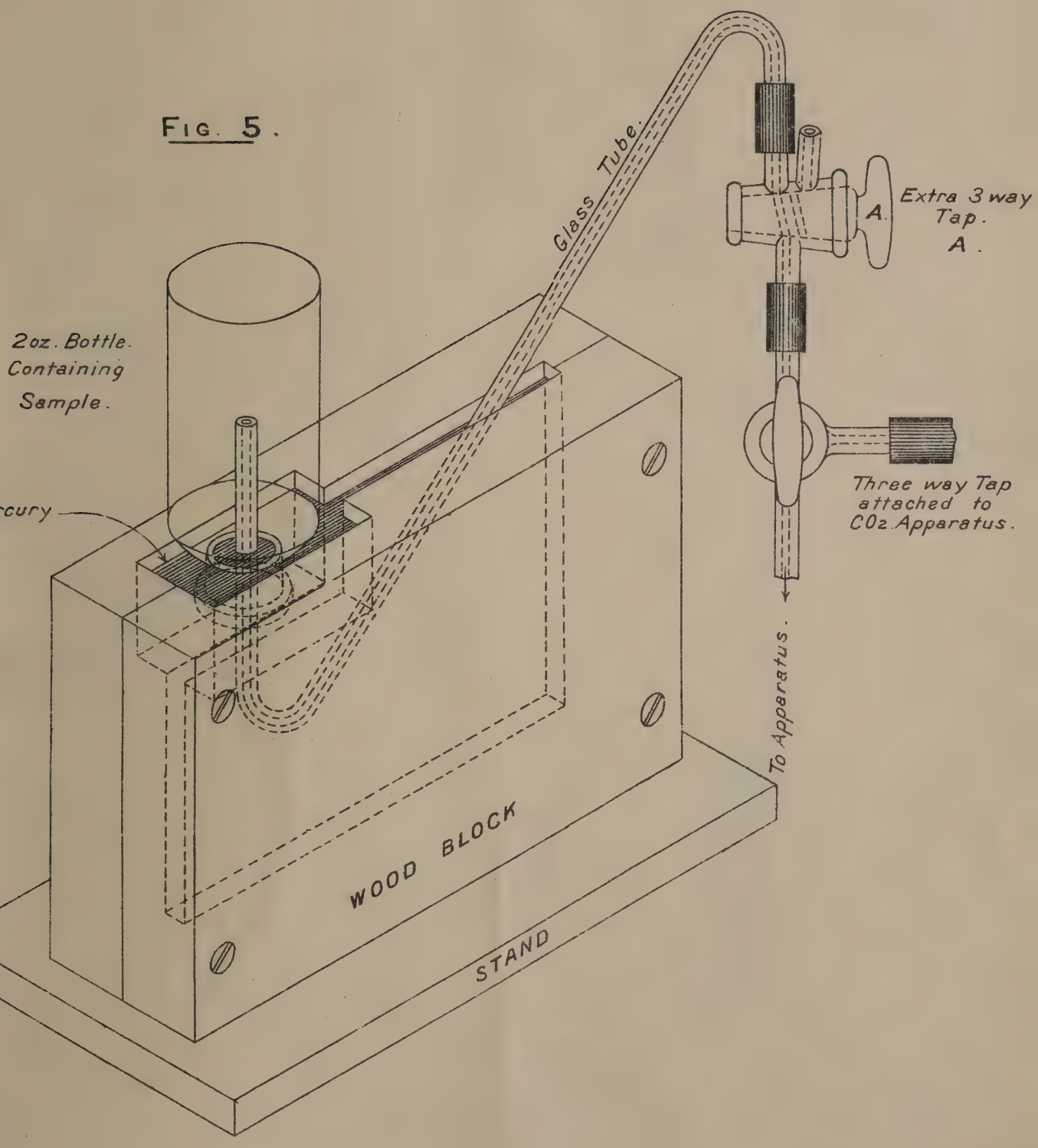
The sample is collected as follows. One end of a piece of rubber tubing about 2 feet long is introduced into the bottle, the other end being held in the mouth. A breath of air is then sucked in, so that the bottle is completely washed out by the air of the room. The tube is removed while the air is still being sucked in, so as to avoid all risk of any of the breath passing backwards into the bottle. The stopper is inserted, turned round, so that no air channels are left through the vaseline, and the elastic band passed over it. The particulars are then written on the label. While the air is being sucked in it is desirable to move forwards 2 or 3 yards, to prevent any chance of the air being locally contaminated by the breath. Care must also be taken that other persons are not too near.

The sample may be enclosed in corrugated paper and sent by post for analysis, or several samples may be sent together in a box holding six or more bottles. Along with each sample a form should be enclosed for entering the result of the analysis ; and the analyst should note whether the bottle is dry, clean, and securely closed.

# Mercury Bath for Extracting Air from 2oz. Bottles.

Scale - ½ Size.

Fig. 5.




C.R.Pendock. del. 30.7.02

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# METHOD OF CONVEYING SAMPLE OF AIR TO $CO_2$ APPARATUS. FROM 1oz. BOTTLE PLACED IN TUMBLER OF WATER.

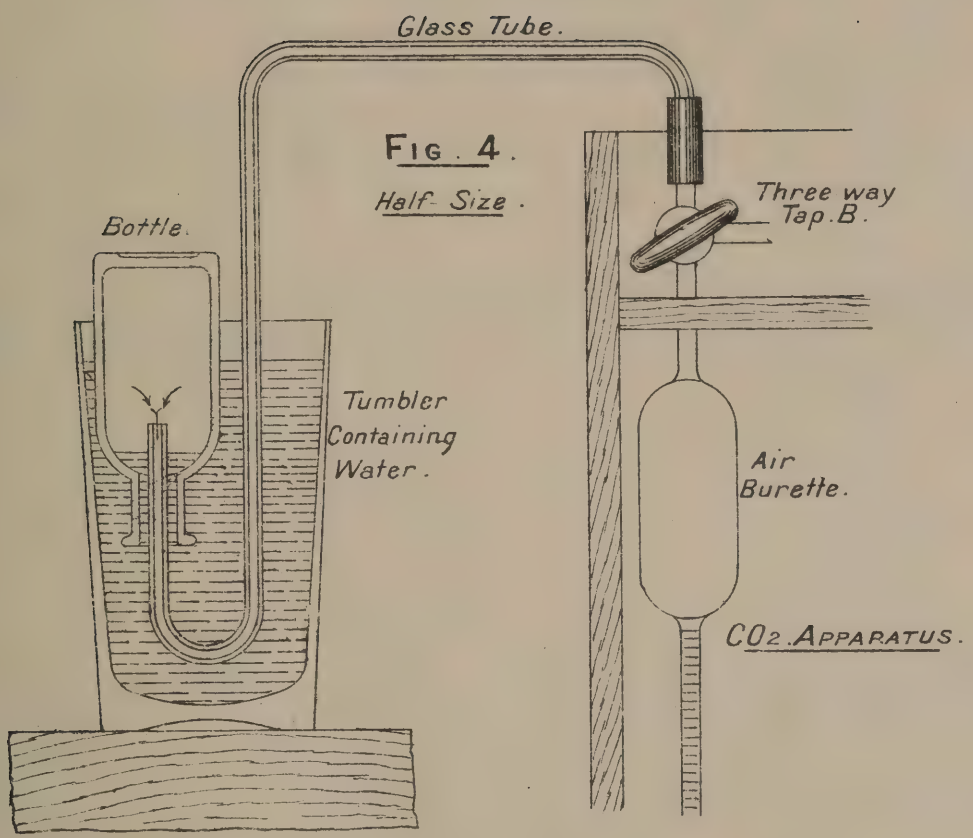


FIG. 4.
Half Size.

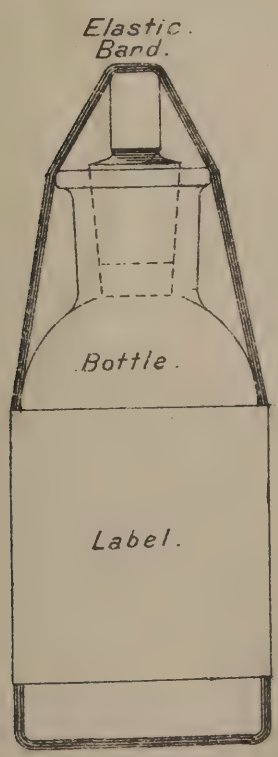



FIG. 6.
2 oz. Bottle for Collecting Samples of Air


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## Appendix III.—*continued.*

For the use of Inspectors of Factories it would be desirable that bottles and boxes of a standard size, provided with locks, should be supplied to each office ready for use, so that no unnecessary loss of time should be incurred in preparing them or sending them off for analysis. Samples sent off for analysis should be in 2 oz. bottles, so as to permit of duplicate analyses when thought desirable.

In order to test the method of taking samples just described, the following experiments were made with 2 oz. bottles of air.

I. Four bottles of outside air collected simultaneously were kept for varying periods and then analysed. The results were as follows :—

| | | Vols. per 10,000. |
|---|---|---|
| Bottle (1) | Analysed at once | (a) 3·0<br>(b) 3·0 |
| „ (2) | „ after 5 days | 2·8 |
| „ (3) | „ „ 9 „ | 3 0 |
| „ (4) | „ „ 19 „ | (a) 2 8<br>(b) 3·0 |

II. Five bottles of air collected simultaneously in a room containing vitiated air were similarly kept and analysed.

| | | |
|---|---|---|
| Bottle (1) | Analysed at once | (a) 51·0<br>(b) 51·4<br>(c) 50·8 |
| „ (5) | „ „ „ | 50·8 |
| „ (2) | „ after 2 days | 51·2 |
| „ (3) | „ „ 6 „ | (a) 50·7<br>(b) 51·0 |
| „ (4) | „ „ 14 „ | (a) 50·6<br>(b) 50·4 |

These experiments show (1) that the carbonic acid does not increase within the bottles; (2) that it does not escape from them to an appreciable extent within a period much longer than would be required if the samples were sent away for analysis.

III. Four samples of outside air were collected in bottles which were both wet and very visibly dirty from dust purposely introduced.

| | | | |
|---|---|---|---|
| Bottle 1. | (Control) | Analysed at once | 3·0 |
| „ 2. | | „ after 2 days | 2·8 |
| „ 3. | | „ „ 6 „ | (a) 8·0<br>(b) 7·6 |
| „ 4. | | „ „ 12 „ | 15·0 |

IV. Five samples of outside air were collected in bottles very visibly dirty from dust introduced, but dry.

| | | | |
|---|---|---|---|
| Bottle 1. | (Control) | Analysed at once | 3·0 |
| „ 2. | | „ after 3 days | 3·2 |
| „ 3. | | „ „ 6 „ | (a) 3·2<br>(b) 3·0 |
| „ 4. | | „ „ 12 „ | 3·0 |
| „ 5. | | „ „ 17 „ | 2·8 |

V. Four samples of outside air were collected in bottles visibly clean, but wet.

| | | | |
|---|---|---|---|
| Bottle 1. | (Control) | Analysed at once | 3·0 |
| „ 2. | | „ after 3 days | (a) 2·4<br>(b) 2·2 |
| „ 3. | | „ „ 5 „ | (a) 2·0<br>(b) 2·0 |
| „ 4. | | „ „ 12 „ | (a) −0·2<br>(b) 0·0 |

Appendix III.—*continued.*

VI. Four samples of vitiated air were collected simultaneously, two being in clean and dry bottles, and two in clean and wet bottles.

| | | Vols. per 10,000. |
|---|---|---|
| | Dry. | |
| Bottle 1. | Analysed at once - - - - - | (a) 20·6<br>(b) 20·8 |
| „ 3. | „ after 9 days - - - - - | (a) 21·2<br>(b) 21·2 |
| | Wet. | |
| Bottle 2. | Analysed at once - - - - - | (a) 21·0<br>(b) 20·4 |
| „ 4. | „ after 9 days - - - - - | (a) 18·6<br>(b) 18·8 |

Experiment III. shows clearly that in bottles which are both wet and dirty the carbonic acid may increase considerably within a few days, so that samples collected in such bottles are useless. The samples collected in dirty but dry bottles showed no increase of carbonic acid, while all the samples in wet but clean bottles gave after some days a slight decrease, due apparently to absorption of carbonic acid by alkali dissolved from the glass by the water. It is evident from these experiments that bottles used for collecting samples *must* be dry, and ought also to be visibly clean.

### 3.—*Positions and Times at which Samples should be Taken.*

As a general rule, it is fairest to collect a sample at about the centre of a room, and not too near any inlet or outlet for air. A sample from the centre is most likely to correspond to the average composition of the air of the room. The purest and the least pure air will probably be found at opposite sides of the room, according to the direction of the wind (*see*, for instance, Table P., Appendix I.). Where, however, the arrangements for distributing air in a room appear to be defective, a sample should be taken in the part of the room where the apparent defect exists. The Committee recommend in the report that in any case where legal proceedings might be involved two samples should be taken at different points, and the average result relied upon. If the means of ventilation on one side of a room are evidently defective, these samples may be taken on that side, but at some yards apart, so as to avoid unduly emphasising the defect. If, however, there is no evident defect in the means of ventilation at one side of the room, the two samples should be taken, either at two positions near the centre or on two opposite sides of the room.

On days when there is definite fog, sufficient to render objects or lights invisible at a distance of more than about 200 or 300 yards, samples should not be taken, for the reasons given in Appendix II. Very windy days ought also to be avoided, as a good result on a windy day does not necessarily indicate that the ventilation is good on other days.

As is fully explained in Appendix II., the composition of the air in a workroom will vary, up to a certain limit, with the time which has elapsed since work commenced ; and, so far as possible, samples should not be taken until a sufficient time has elapsed.

Similarly, if gas has been burning in a room before daylight in the morning, a reasonable interval should be left for the extra carbonic acid to disappear before a daylight sample is taken. An interval of an hour is recommended in the report. Where gas is burnt by daylight, either for lighting or for heating, the ordinary daylight standard of carbonic acid ought, in the opinion of the Committee, still to apply, except, of course, on days of fog, when artificial light may be necessary in any building.